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Reentered as second class matter July 19, 1951, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Established in 1929 as Metals and Alloys.

The Materials Outlook

Pastel-colored phenolic moldings seem to be on the way. Laboratory developments are promising but it will be another year or more before the new molding compounds are available in quantity. Phenolics with improved chemical resistance and greater arc resistance are also being developed. Substantial improvement in any of these directions will tend to increase the use of phenolics at the expense of ureas and melamines, since phenolics are much cheaper and easier to mold.

Metal powder strip is now being produced in this country by a process claimed to be economically practical. Thin strip can be produced, and composite strip, such as iron on one side and copper on the other, is also possible.

Pre-plated investment castings are being produced by British molders. A low melting alloy pattern is plated with high melting metals, such as copper plus chromium. After investment and drying, the mold is heated to melt out the pattern, but the higher-melting plate remains as a mold lining. The casting metal is poured while the mold is still hot, and it bonds with the metallic lining.

A radically new technique for rapid drying of organic coatings without the use of heat has been developed. Called Chem-Dry, the process is based on the reaction of sulfur dichloride vapor with the resins and oils in the coating. Exposure to the vapor for 2 to 20 sec produces an initial set, and hardening is completed without contact with the vapor in a matter of minutes. This chemical method substitutes cross-linking of molecules for the usual oxidation and/or polymerization.

A ductile steel powder has been developed in Germany. The powder is produced from the molten phase and grain size can be closely controlled. Lack of the brittleness generally characteristic of ferrous alloy powders may lead to expanded applications for these metal powder parts.

The days of rock-bottom zinc and lead prices may be numbered. Acting on a request by the National Lead and Zinc Committee, an industry group, the U.S. Tariff Commission is now holding public hearings to determine whether changes should be made in existing tariffs on shipments of the two metals coming into this country. Under the Trade Agreements Extension Act, this country can raise its tariffs if the Commission and the President decide imports are seriously injuring the domestic industry.

Aluminum can now be coated with strongly-bonded films of polytrifluorochloroethylene. Thickness of the film ranges from 0.005 in. upward, the

(Continued on page 4)

optimum being about 0.010 in. The coating is claimed to have no pinholes and will remain undamaged when the base metal is bent or otherwise deformed.

All-magnesium aircraft are being seriously considered by the Air Force. The lighter weight of magnesium, compared to aluminum, allows thicker sections to be used with no increase in weight. Thicker sections, in turn, eliminate the need for many stiffening members and fasteners, thus lowering design and production costs considerably. So far tests have been conducted mainly on aluminum structures redesigned for magnesium, so that the full possibilities of magnesium design are not yet known.

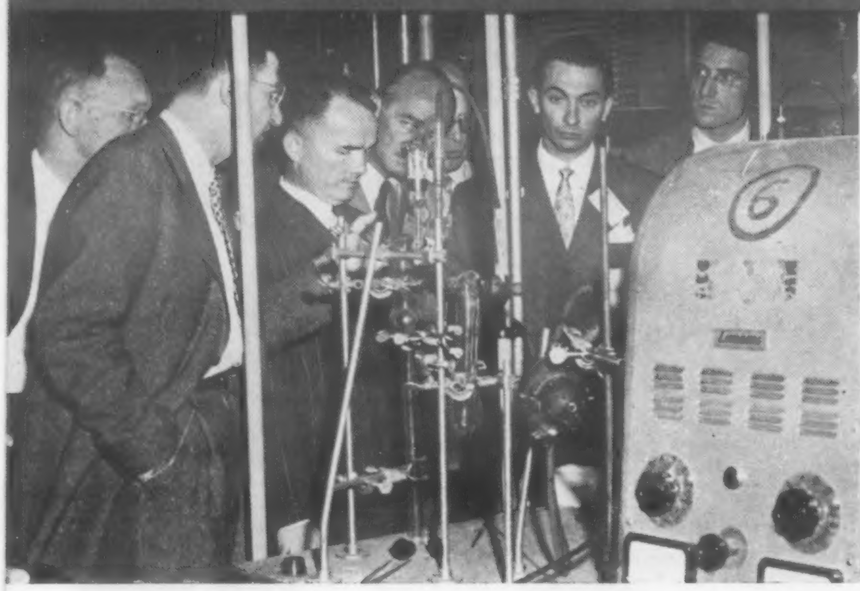
Oriented ferrites with a maximum BH product of about 3 million are expected to be available commercially in Holland and England within a few months. Values of 4 million have been achieved in the laboratory, with orientation being obtained by use of an intense magnetic field during pressing. Fabrication is complicated by the slow pressing cycle needed to allow orientation and the need for demagnetization before removal from the die. . . . Powder metal magnets of copper-nickel-iron alloy are being produced in England. Experts disagree as to whether these materials can ever compete with the alnicos, but they seem to agree that the ferrites can and will.

Lower cost shell molding is foreseen by promoters of this relatively new foundry process. One source predicts that the amount of phenolic resin needed per mold may eventually be cut in half as a result of improvements in technique. Currently, shell molds contain about 6% resin by weight.

Two essentially nonadhesive materials- the fluorocarbons and the silicones- have now been combined into a pressure-sensitive tape. The tape consists of a fluorocarbon film to which is bonded a new silicone adhesive. The result is a highly chemical- and heat-resistant adhesive tape suitable for use at temperatures from -65 to 300 F.

Electroplates on iron powder parts capable of meeting rigid government specifications are claimed to be achieved by means of a new process. A series of eight operations, including impregnation under high vacuum, is used to prepare the surface for plating. Coatings of copper, nickel, chromium, zinc or cadmium that are not absorbed and do not migrate can then be obtained by conventional electroplating techniques. Mirror finishes are possible.

New tinted safety glass for TV cabinet protective windows has been developed by two major companies. In both cases, a neutral tint has been incorporated in order to control light transmission and thus enhance contrast of the picture tube under a wide range of external lighting conditions. In one glass sandwich, the color has been added to the vinyl interlayer; in the other it has been added to the glass. Color in the glass itself is claimed to make it possible to vary the thickness of the interlayer according to the implosion requirements without affecting light transmission characteristics.



Laboratories and production equipment were on display to visiting European powder metallurgists last month as they toured the country under Foreign Operations Administration Point 4 sponsorship. *Sylvania*

Lectures and discussion periods after each plant tour provided an opportunity for the represenstatives of seven European countries to clear up questions on production and research. Here they listen to Dr. Schwartzkopf of American Electro Metal Corp.

Point-4 Points to Powdered Metal:

Visiting Scientists Survey U.S. Production

A friendly invasion of 31 powder metallurgists representing 8 countries arrived in New York on Sept. 30. Here under the auspices of the Foreign Operations Administration as part of the Point-4 sponsored Organization for European Economic Co-operation, the group immediately swung into a concentrated 37-day study of U.S. research, production, and application techniques in powder metallurgy.

After a day of orientation lectures, the group split into four sub groups according to specific interests for plant visits to take a first hand look at American production in action.

The status of world progress in powder metallurgy was reviewed for the visiting scientists by leading educators, journalists and research men active in American concerns. Kempton H. Roll, Assistant Secretary of the Metal Powder Association, summed up the purpose of the project in an orientation lecture to the group. He pointed out that the science of powder metallurgy actually saw its greatest early development in Europe and that European metallurgists evolved the theories which are the basis for the industrial application seen in this country today. Due to wartime dislocations, however, this country has forged ahead of Europe both in applying the techniques of powder metallurgy and in scientific research. He pointed out that the reasons behind the rapid development of powder metal use here—economies in materials and reduction of machining and skilled labor requirements—were doubly applicable in material and skilled-labor short Europe. Development of powder metals in Europe has lagged, largely because about all of Europe's industrial facilities have been concentrated on reconstruction rather than development of new methods and materials.

In a discussion period after a plant tour of Sylvania Electric Products, Inc., the visiting scientists discussed the progress and industrial status of

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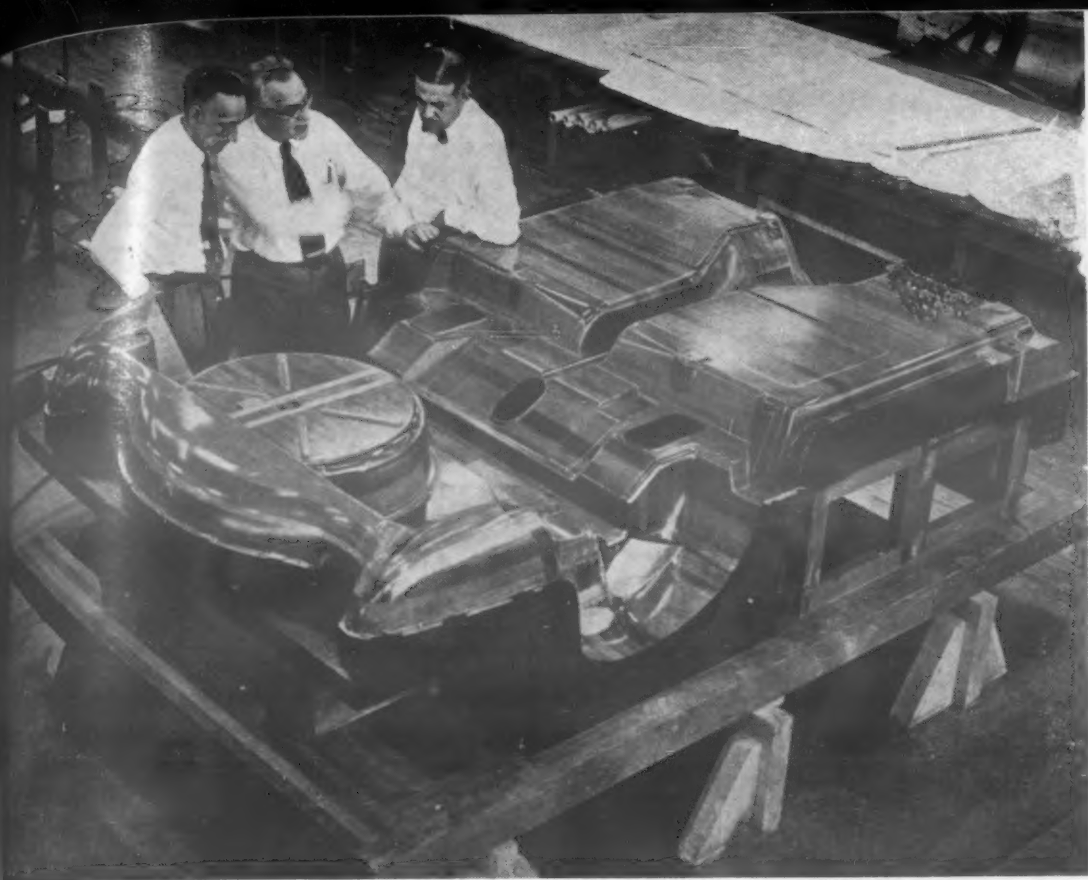
Materials Conference Proceedings Published

Papers read at the Basic Materials Conference last June will be published by Clapp and Poliak, producers of the Conference and concurrent Exposition. In book form (265 pp, $7.50), "Materials for Product Development—1953" covers discussion of a wide range of modern production materials.

The 2nd Basic Materials Conference and Exposition will be held in Chicago's International Amphitheater May 17-20, 1954.



Low cost dies, such as this solid mahogany underbody form for the Corvette, can be made in a hurry and used in pilot production of large plastic moldings. For a faster production cycle, matching soft metal dies are used.

Reinforced plastic body components lined up in front of finished car represent five of the sixty moldings.

G. M. Schedules Production of Plastic Car Bodies

New Facilities to Turn Out 1000 per Month.

Reinforced plastics for automobile bodies will get their first large scale production test early in 1954. General Motors will produce, in volume, an all plastic body for the Chevrolet Corvette sports car, and the future of basic materials for automotive bodies may depend to a large extent on Chevrolet's experience with the reinforced plastic material. As the first plastic production model to come off an assembly line of a member of the big three, a lot of eyes besides those of prospective buyers will be on the Corvette's performance, cost and production methods. If the material lives up to even half of the potential qualities unveiled recently by Chevrolet, steel can look for some stiff competition in the not too distant future.

According to the experience of the General Motors Experimental Div., the most challenging attribute of large laminated polyester moldings is low tooling cost and short transition time between drafting board and production line. Chevrolet engineers estimate that the entire tooling cost for the 60 plastic moldings that make up the body, dash and underbody of the Corvette will be under $500,000. The same body in steel would require dies costing about $4½ million. They point out that the present Corvette body was first shown as a plaster model at a display in January 1953 and production stemmed from the interest that was aroused at that time. Limited production started five months later. The same model produced in steel would have required several years for tooling.

Total Corvette production in 1953 will be about 500 bodies, but a new plant for plastic moldings will be completed in Ashtabula, Ohio in December and new assembly facilities in St. Louis will turn out about 1000 cars a month early in 1954. The car will be priced around $3500 (including a hopped-up Chevrolet 150 hp engine with three carburetors and dual exhausts).

At present all the plastic components that go into the body are produced by lay-up bag-molding. Woven or compacted mats of glass fibers are layed on mahogany forms, painted or sprayed with liquid polyester resin and catalyst, and then placed, mold and all, inside a large airtight bag. The air is then exhausted from the bag, and atmospheric pressure molds the plastic to the die as curing takes place. This process is not only slow and cumbersome, but produces a rough surface that must be sanded before finishing. A much better finish can be obtained from matched metal dies which also can be heated to provide a faster curing cycle. The new facilities at Ashtabula will use the matched die process.

Final finishing of the polyester moldings for the Corvette results in a paint job similar to the finish on steel automobile bodies. The basic body components are fabricated in an unpigmented colorless state and are coated with a baking primer and final coat of medium-baking, synthetic enamel. The enamel and primer fill the pores in the molding and prevent water adsorption by capillary action.

The glass laminate bodies have a better strength-weight ratio than steel,

and the superior resiliency of the plastic eliminates denting. If the skin is punctured or torn by severe stress, repairs can be made quite simply with a patch of glass fiber and plastic. Well-made repairs are virtually invisible and are quite strong.

Little difficulty has been experienced in fastening the plastic body to the frame of the car, as the coefficient of expansion of plastic is close enough to that of steel to allow direct bolting to structural members. Plastic to plastic joints utilize both bolting and adhesive bonding.

With production of the plastic sports car scheduled for 1000 per month, it will be scarcely more than a small pilot operation compared to total car production. But as such, it should be a center of attention for material engineers, suppliers and market analysts, as production problems and high costs will be attacked as never before.

Unscrambling the Alphabet:

Dept. of Commerce Lines up BDSA

The Business and Defense Services Administration (BDSA) of the U. S. Dept. of Commerce, was chartered on Oct. 1 in hope of clearing the heavy broth surrounding the alphabet-soup of Department of Commerce agencies. Many of the departments changed, created or realigned in the move are directly important to the hard-goods materials field. Here is the new line-up. . . .

The BDSA is an entirely new agency which will:

1). Continue the residual functions of the former National Production Authority (NPA).

2). Consolidate five current departmental offices of the Department of Commerce.

3). Establish 25 new Industry Divisions which will handle defense, mobilization and business service activities.

The purpose of the BDSA, according to the Department of Commerce, is to provide a focal point for effective cooperation and exchange of information between government and business.

The five existing Department of Commerce offices which are now under the BDSA are: the Office of Technical Services (OTS); the Office of Distribution; the Field Service; staff functions of the Industry Evaluation Board; and the Office of Industry and Commerce (including the OIC Trade Association, Commodities Standards and Area Development Divisions).

The BDSA is under the authority and Supervision of the Assistant Secretary of Commerce for Domestic Affairs and is directed by an administrator. As yet, there have been no permanent appointments to either of these posts. Carl F. Oechsle is Acting Assistant Secretary of Commerce for Domestic Affairs and H. B. McCoy, former Acting Administrator of the now defunct NPA has been appointed Acting Administrator of the BDSA. Mr. McCoy has also been appointed permanent Deputy Administrator.

BDSA Staff Offices

The BDSA will have three Staff

(Continued on page 216)

What They Said . . . . . .

REINFORCED PLASTICS "Perhaps some day in the future automobile bodies will be made of some plastic material, but accomplishment of this is so remote it is deserving of only 'possibility thinking.' Some of our contemporaries have prophesied the production of bodies by low pressure molding of plastic impregnated fibrous material of various kinds. This is a spectacular suggestion which in the light of remarkable wartime uses of this technique seems reasonable at first glance. However, without going into technicalities, it is necessary only to point out that the optimum molding cycle is far too slow to keep pace with automobile production."—*C. W. Sundberg, Feb. 1945.*

STEEL "It has been demonstrated that approximately 3 tons of high strength steel are equivalent to at least 4 tons of carbon steel. . . . For every ton of carbon steel consumption rendered unnecessary by the use of high strength steels, our natural resources are conserved by 1.8 tons of iron ore; 1.4 tons of coal; 0.5 tons of limestone, and 0.3 tons of purchased scrap and other materials—a total saving of raw materials out of all proportion to the small quantities of the alloying elements consumed in the manufacture of these superior steels."—*A. F. Stuebing, U. S. Steel Corp., June 16, 1953.*

MACHINABILITY TRACERS ". . . by use of tracer techniques, tool wear and tool life can be measured more rapidly, with less cost and more precisely than by conventional methods. Thus, many, many more tool life measurements can be made now than in the past and, thus, many more determinations can be made on those factors which are going to improve tool life and reduce costs in industrial machining operations."—*M. Eugene Merchant, Assistant Director of Research, Cincinnati Milling Machine Co., May 25, 1953.*

Materials BRIEFS

Be A Weight Watcher If you use the weekly steel production announcement as an economic indicator, watch the tonnage figure rather than per cent of capacity. More steel is now made at 95% capacity than at the 100% rate a year ago. 88% of capacity now produces steel at a greater rate than during the most active week in 1950 when production was 103%.

Plastic Pipe The first all plastic cross-country pipe lines are in operation at Williston Basin. The three-inch butyrate pipe can move more than 2500 barrels a day at an operating pressure of 90 lb. Construction was reported to be far easier than a steel pipeline, as the extruded pipe sections weigh only 13 lb per 20 ft length.

Do It Now The American Standards Association urged business management to prepare uniform standards in advance of developments in the use of electronics and atomic energy in private industry. If standards are not established now, the association warned, industry will have to build them later and unscramble a fantastic mess.

Glass Fiber Paper Paper companies are calendering paper from extremely fine glass fibers. Incombustible, the paper is used in electrical laminates, filters for hot corrosive gases and liquids, and as plate separators in batteries. Manufacturers feel that they have not yet scratched the surface of the number of its uses.

Quiet Please A major producer of acoustic materials reports that demand for sound deadening products prompted the company to double capacity for the production of sound control products by January 1954.

Flash Power Pilot plant production of a powdered magnesium fuel suitable for small internal combustion engines is underway. Initial claims rate one pound of the magnesium fuel (production cost: 56¢) equal to 10 gal of gasoline. Special engine to run on fuel would require fewer moving parts, and would be less costly to produce.

New Phenolic-Glass Laminates for Elevated Temperatures

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

Recent developments in reinforced plastics indicate that they, rather than metals, may be the answer for some structural applications in the 300-500 F range.

● ANY SUGGESTION THAT plastics might replace metals in some structural applications because of superior properties at elevated temperatures is likely to be greeted by most engineers with something less than courtesy. Yet a new family of reinforced plastics still under development may soon do just that.

The new material is basically similar to the polyester-glass low pressure laminates which have already found broad usage in both civilian and military applications. Instead of a polyester resin, however, these laminates use a phenolic resin. The phenolic resin greatly improves retention of physical properties in the temperature range of 300 to 500 F. On the other hand, it also introduces fabrication problems not associated with conventional low pressure laminates.

Inasmuch as most of the work on phenolic-glass low pressure laminates has been done in connection with national defense applications, not much data is available as yet. It is the purpose of this article to summarize what little data is available and to point out the important possibilities, as well as the limitations, of this new material.

Why This Material?

The position which polyester-glass reinforced plastics have already achieved in the aircraft industry will not be discussed here as the facts are rather widely known. Primarily, their acceptance has been due to low manufacturing costs; favorable strength-weight ratio, compared to the light metals; and, in the case of radomes, to their lack of radar interference. Chiefly responsible for the emergence of the new phenolic-glass material is the current trend in operational development of military aircraft and guided missiles—namely, higher and higher speeds. Having eased through the sound barrier relatively unscarred, today's aircraft designers must now overcome a heat barrier. The nature of this barrier is illustrated by the graph in Fig. 1. At the speed of sound, which is 760 mph (1.0 Mach No.) at sea level, temperatures can reach 190 F. At 1100 mph they can exceed 300 F, and, theoretically, at twice the speed of sound they can exceed 500 F.

At such temperatures the strength and stiffness of aluminum and magnesium alloys drop appreciably. One expert says: "If it were possible to attain a speed in any of our present aircraft that would produce a temperature of 500 F, the strength of these structures would be reduced to about 75% of normal and the deflections of their wings, fuselages and tail surfaces under loads would be magnified four times." Such deflections would probably make the control surfaces ineffective.

Polyester-glass materials vary widely in their elevated temperature properties. Some modified types retain a significant proportion of room temperature strength in the 300-500 F range. In general, however, these properties deteriorate during prolonged exposure and the level of strength and stiffness is not high enough to offer appreciable advantage. As a result there has been much interest in reinforced plastics with other resins, such as epoxies, furanes, phenolics and silicones. The silicone-glass materials are of particular interest because of the well-known resistance of silicones to thermal degradation. Unfortunately, the silicones do not offer initial high strength and stiffness. Of all the combinations developed so far, the

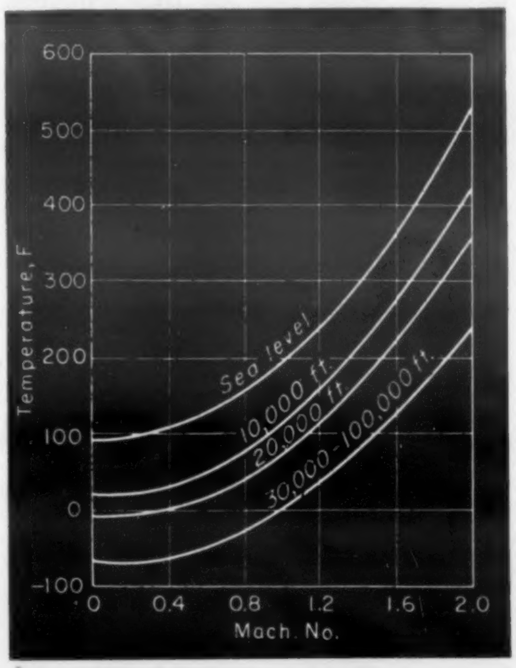


Fig 1 The coming temperature problem is illustrated by this graph which shows the maximum theoretical rise in temperature with Mach Number and altitude for a typical hot summer day (steady state conditions). Adapted from a paper by J. M. Stevens, Bureau of Aeronautics, Feb. 18, 1953.

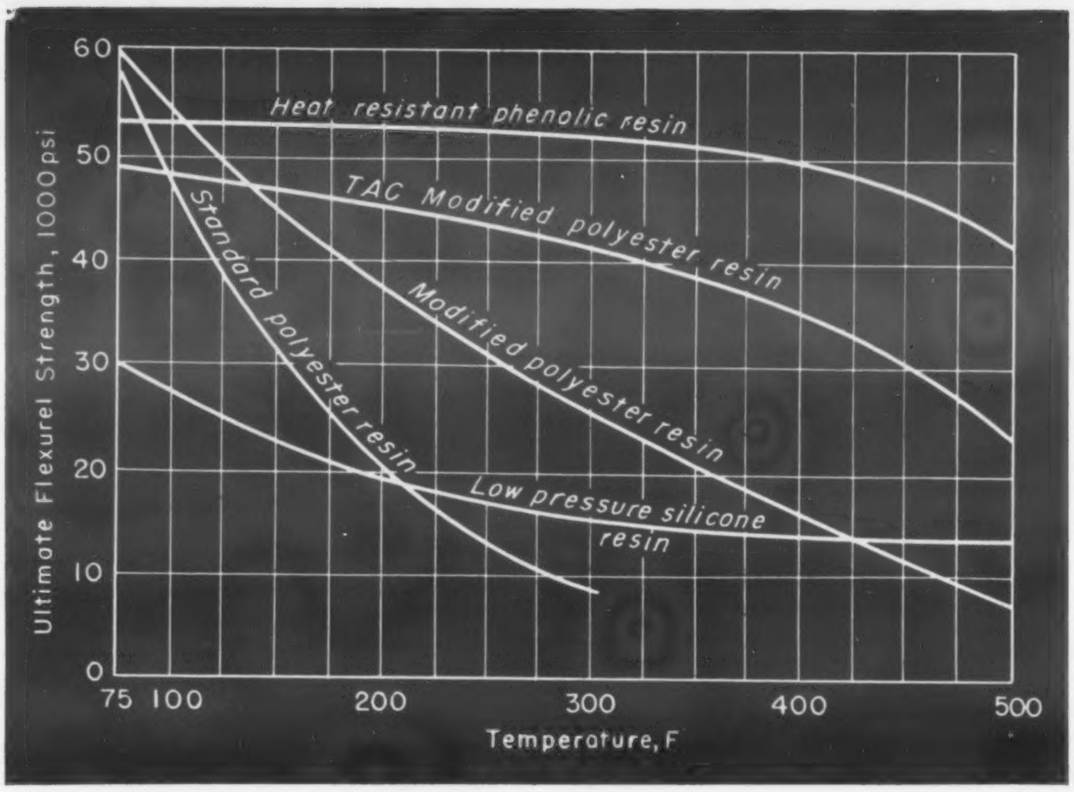


Fig 2 These flexural strength curves show why attention is being directed toward phenolic resins for glass laminates, rather than polystyrenes or silicones, for elevated temperature service. Laminates based on 181-114 fabrics were tested after ½ hr of temperature. (Adapted from paper by J. M. Stevens, Bureau of Aeronautics, Feb. 1953.)

phenolic-glass materials appear to offer the most promise. A general idea of the relationship among polyester-, silicone- and phenolic-glass materials is given by the curves in Fig. 2. As will be shown later, the phenolic-glass materials are markedly superior not only to other reinforced plastics but also to the light metals in the 300-500 F range.

Any comparison of this sort has one serious weakness: it assumes a static relationship. Although it is generally believed now that aluminum and magnesium alloys have about reached their peak of heat resistance, tomorrow may see another unexpected improvement. And just recently a new polyester resin was introduced which is claimed to offer strength retention at elevated temperatures superior to all conventional types. Furthermore, it should be emphasized that both stainless steel and titanium are being seriously considered, along with phenolic-glass, for these new applications. The special interest in phenolic-glass rests on two important points: it is available and it offers many of the advantages commonly associated with reinforced plastics.

Advantages and Limitations

Outside of high strength retention at elevated temperatures, the characteristics of phenolic-glass which make it attractive to the designer are, to a large extent, those of reinforced plastics in general. Since this subject has been well covered previously (M&M Manual No. 91, February 1953) these characteristics will not be discussed in any detail. Here, briefly, are listed some of the advantages that may be important for different applications:

1. Materials used are almost completely non-critical.
2. No corrosion problem.
3. Can be easily formed in complex shapes.
4. Light weight.
5. Joints can be virtually eliminated in design, making possible a high degree of surface smoothness as well as lower assembly costs.
6. Easy control of section thickness and fiber direction makes possible designing for local stress conditions.
7. Low cost tooling.
8. No need for highly skilled labor.
9. Low floor space requirements in fabrication.
10. Easy repairs and servicing in field.

In addition there are the special advantages in military aircraft applications of low radar reflectance and less vulnerability to damage by gunfire (reinforced plastics are pierced cleanly while metal tends to tear).

Chief disadvantages of reinforced plastics which these materials share to some extent are:

1. Low modulus values.
2. Decrease in strength upon prolonged exposure to moisture and high relative humidity.
3. High materials costs.
4. Fabrication methods unsuitable for high production.

From the standpoint of design, the low modulus is probably the chief deterrent to use of phenolic-glass. Even on a weight-for-weight basis, the moduli of currently available types do not compare favorably with those of metals at room temperature. At elevated temperatures, however, the moduli drop only slightly while those of the light metals sag sharply, and phenolic-glass offers greater stiffness. Nevertheless, the modulus values, even at elevated temperatures, are much lower than those of stainless steel and titanium. The low modulus values at ordinary temperatures mean that thicker sections would have to be used in many cases, and it is unlikely that any overall weight saving would be achieved by use of phenolic-glass.

Continuing development of phenolic-glass, however, raises the prospect of appreciably higher moduli, as well as much less moisture absorption. Improvement seems to hinge partly on the extent to which new finishes for the glass are compatible with the phenolic resins. These finishes provide better wetting of the glass by the resin and thus reduce internal voids. So far it has not been possible to take full advantage of these new finishes except with a resin that requires altering the fabrication methods to such an extent as to make the presses currently used by most reinforced plastics laminators inapplicable.

Cost of phenolic-glass materials runs about the same as polyester-glass and can be figured roughly at about $2.50 per lb for impregnated cloth. This is high compared to aluminum alloy sheet at about 45¢, magnesium at 65¢ and stainless steel at 40 to 65¢ per lb. It is low compared to $15 per lb for titanium sheet. In many cases, the relatively high cost of phenolic-glass is easily offset by lower costs of fabrication.

Unlike polyester-glass materials, phenolic-glass cannot be fabricated by wet lay-up. In matched tool molding, the pressures must be somewhat higher than those generally used for polyesters, since pressure is required

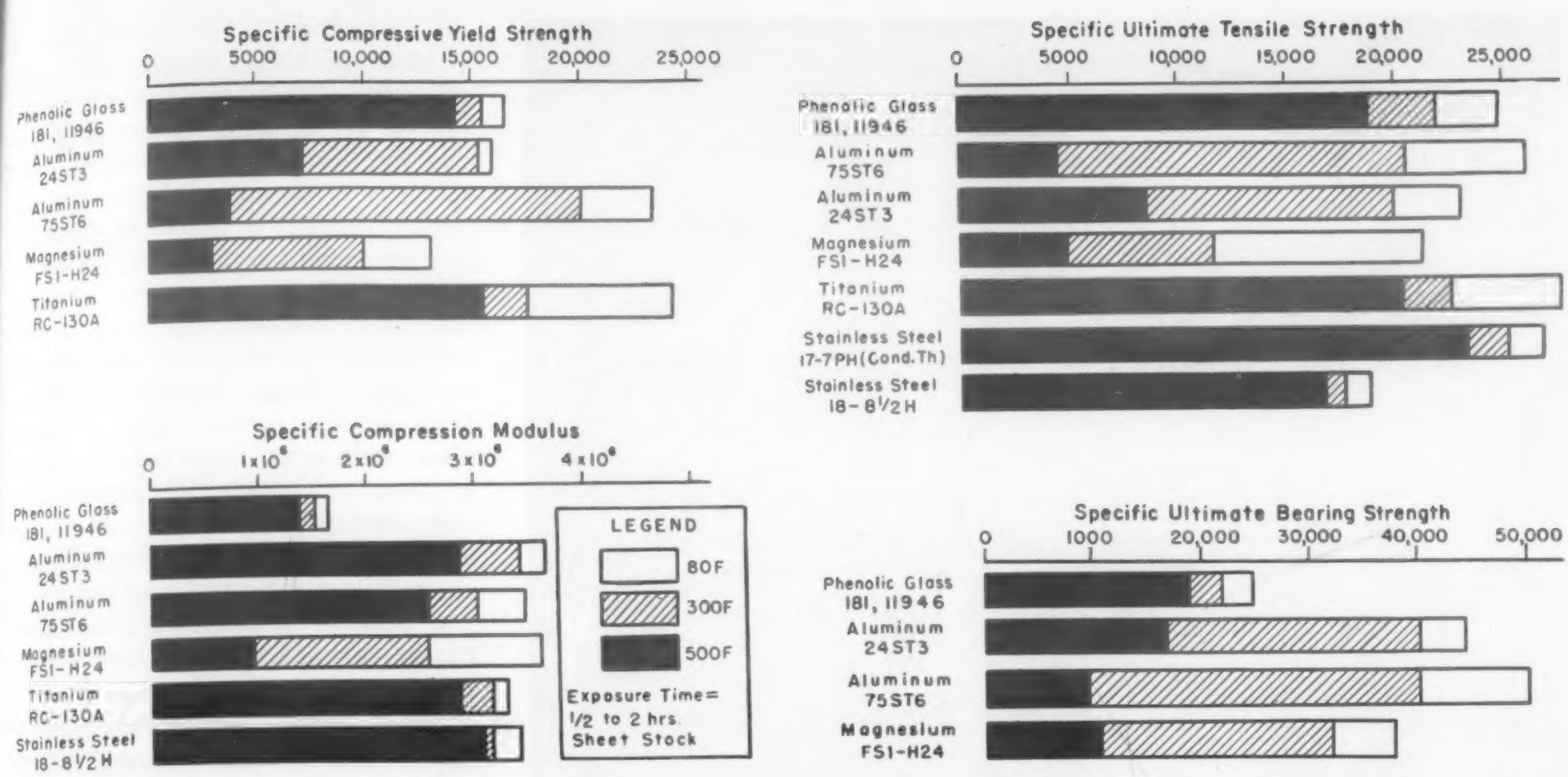


Fig 3 A weight-for-weight comparison of phenolic-glass and other materials showing the proportion of room temperature properties retained at 300 and 500 F. The figures represent properties in psi divided by specific gravity of the material. (Adapted from a paper by William E. Braham, Zenith Plastics Co., April 10, 1953.)

not only to shape the part, but also to eliminate internal voids resulting from loss of phenolic condensation reaction products during curing. In addition, phenolic-glass requires a post-cure on the order of 24 hr in order to develop maximum properties. A post-cure is sometimes used to improve polyester properties but, in general, all these factors represent departures from conventional low pressure laminating. By complicating fabrication problems they reduce somewhat the advantages ordinarily gained by use of reinforced plastics. Since the aircraft industry is not, except perhaps in wartime, a mass production industry, the lengthy molding and curing cycle is not regarded as too serious an obstacle to aircraft applications.

A limitation of all reinforced plastics peculiar to aircraft design is the erosion of such materials upon impact with rain at high speeds. A neoprene coating would probably be used to protect leading edges of wings and tail surfaces. All other surfaces would be protected by an ordinary organic finish.

The Materials

The phenolic-glass materials generally contain 35 to 40% by weight of resin. Three companies are producing or developing heat-resistant phenolic resins specifically for low pressure glass laminates. They are Cincinnati Testing and Research Laboratories, Bakelite Co. and General Electric Co.

The two resins that have received the most attention are Cincinnati's CTL-91-LD and Bakelite's BVQ-11946. Both are being used currently in aircraft developmental applications. The fabrication procedures discussed in this article apply to these two resins in particular. Another Bakelite resin, BV-17085, when used with glass cloth that has been treated with one of the improved finishes, offers markedly superior properties. Its application, however, is currently limited by the longer molding cycle required. Also under study is General Electric's 12304 resin and a new GE resin, S-1072, just recently introduced. Of these, the latter seems to offer the greater promise for elevated temperature applications.

All of the data available so far has been obtained on materials utilizing 181 glass cloth. This is essentially a nondirectional cloth. Warp and fill densities are about equal which means that strength in the fill direction is about equal to that in the warp direction. Although laminates have been made by building up layers at 45-deg angles, most available data is for laminates in which the warp direction is constant. Higher properties in the warp direction could be obtained with some unidirectional glass cloths.

Glass finishes 114, 136 and Volan A have been used. Du Pont's Volan A is one of several new finishes, including Garan, Bjorksten BJ-Y and Owens-Corning OC-136, which are expected to reduce internal voids in reinforced plastics by permitting better wetting of the glass fibers by the resins. Although this finish appears to produce marked improvement in properties when used with BV-17085, it is incompatible with the more practical BVQ-11946 resin.

As mentioned earlier, the heat-resistant phenolic resins are not suitable for wet lay-up molding due to the foaming of solvent that results during subsequent curing. Therefore, phenolic-glass low pressure laminates are molded exclusively from pre-impregnated sheet stock which has been partially precured for ease in handling and storage. Although the resins themselves have limited shelf life, the precured impregnated sheet can be stored indefinitely. The necessity for using pre-impregnated sheet has, up to now, prevented the use of glass mat which is often cheaper than the cloth. However, one company reports that it has overcome the technical difficulties that have blocked the development of a continuous process for pre-impregnating glass mat. It expects to have at least one form of pre-impregnated mat on the

Fig 4 Comparative properties of phenolic-glass and metals after 1/2-hr exposure (left) and 200-hr exposure (right) at various temperatures. (Adapted from a paper by Elmer P. Warnken, Cincinnati Testing & Research Laboratories, May 19, 1953.)

market shortly. The mat will have about 70% of the strength of 181 fabric, and will cost about half as much.

At this point, passing reference must be made to another material similar to phenolic-glass on which still less data is currently available. It is composed of asbestos fibers about 3/16 to 3/8 in. in length impregnated with phenolic resin. Known as "Durestos", it is being used on a fairly wide scale by the British, not only in aircraft and guided missile development but also in the automotive and electronic industries. According to a recent report, one of these materials has an elastic modulus of 9,000,000 psi, shear modulus of 1,000,000 psi, tensile and compressive strengths of at least 40,000 psi, with no appreciable change in properties between –65 and 500 F. Asbestos, of course, is readily available in Great Britain, whereas glass fiber is more easily obtainable here.

Properties

Many different factors affect the test properties of phenolic-glass low pressure laminates. The most important are: 1) the particular resin, 2) the proportion of resin, 3) the type of glass cloth, 4) the type of finish on the glass, 5) the relative direction of the laminations, 6) the thickness, 7) the molding pressure, 8) the curing cycle and 9) the test direction.

Some of these factors have been discussed already, but an understanding of all of them is necessary for any intelligent appraisal of test results. For instance, higher tensile strength values in the warp direction can be obtained by reducing resin content to a certain extent. Such materials, however, are usually unacceptable because of low bond strength. Some experts say thin laminates are much stronger than thick laminates, especially in compression (although this statement is not universally accepted). Mechanical properties can be generally increased by raising molding pressures, and also by post-curing for longer periods or at somewhat higher temperatures.

With such factors in mind, it is hoped that the data included in this article will be viewed with a proper degree of skepticism based on these three facts: 1) the data is fragmentary, 2) the pertinent factors listed above are not specified for all such data, and 3) the data is not necessarily representative of what will be achieved as development continues.

A fairly good idea of why phenolic-glass is of interest to designers of guided missiles and military aircraft can be found in the bar charts in Fig 3. These charts show how this material retains its physical properties during short exposures to elevated temperatures in comparison with alloys commonly used or now being contemplated for aircraft construction. Only stainless steel and titanium have an edge when the materials are compared on a weight-for-weight basis. These charts also underline one of the major limitations of phenolic-glass—its low elastic modulus.

There is another way of looking at comparative strengths that makes phenolic-glass more attractive than

Table 1—Water Absorption and its Effects

Resin	Resin Content, %	Glass Fabric and Finish	Dry: Flex Str, psi	Dry: Mod of Elasticity, psi	Water Absorption after 24 hr, %	In Water—After 15 Days: Flex Str, psi	In Water—After 15 Days: Mod of Elasticity, psi
BV-17085	37	181–136	47,000	2.90	2.14	39,300	2.59
BV-11946	38	181–136	50,600	2.50	1.77	39,200	2.48
BV-17085	32	181–Volan A	66,300	3.78	0.24	60,600	4.16

Note: Test specimens measured 3 x 1 x 1/8 in.

Adapted from data provided by Bakelite Co.

stainless steel. When stressed in tension or bending the reinforced plastic does not deform before fracture. This means that for the purposes of most design, the ultimate tensile or flexural strengths of phenolic-glass are comparable to the yield strengths of most metals. When such comparisons are made, even on an absolute basis as in Fig 4, the advantages of this material at elevated temperatures are more obvious.

The comparisons in Fig 4 are based on short time exposures and on a prolonged exposure—200 hr. The phenolic-glass material loses considerable strength at sustained temperatures above 400 F, whereas stainless steel drops only slightly. Although phenolic-glass tends to lose its position relative to stainless, long exposures do not affect its marked superiority to the light metals.

Actually, the data on the effect of long exposures at elevated temperatures is rather inconclusive. In some tests the material has actually shown improvement in properties after heat aging tests. Available data suggest a tendency for the properties to level out after 50-100 hr at temperature. No data on creep or impact strength are available.

The elastic modulus of phenolic-glass currently available ranges from 3.25 to 3.75 x 10^6 psi, at room temperature, with values as high as 6.50 claimed for materials still under development. Its decline at temperatures in the 300-500 F range is claimed to be no greater than 10 to 15%. Moduli of the light metals are believed by some to fall as low as 2.0 x 10^6 psi at such temperatures.

Results of water absorption tests on two materials are given in Table 1. The Volan A finish appears to significantly reduce internal porosity, thereby minimizing the effects of moisture. Electrical properties of two other materials are shown in Table 2.

Fabrication

Except for wet lay-up, all the principal fabrication methods for reinforced plastics can be applied to phenolic-glass. These include cellophane lagging, bag molding (either pressure or vacuum), press forming and matched tool molding.

Molding pressures generally range from 30 to 70 psi. There is some disagreement over what pressures are required to produce a "reliable" phenolic-glass laminate, with one set of experts holding out for 200-400 psi. In any case, the molding pressures used with this material are definitely higher than those used with polyester-glass but, in comparison with those used for high-pressure moldings, they can properly be termed "low".

Molding cycles vary with the particular resin and thickness and area of the part. A typical molding cycle for lagging or bag molding might be 30 min with a maximum temperature of 290 F. A typical molding cycle for matched tool or press molding is to preheat the press to 260 F, apply contact pressure and maintain it for 15-60 sec, then increase pressure to 30-60 psi and maintain it about 10 min per 1/8-in. thickness. The laminate can be removed hot. An alternative (where the press heats up rapidly) is to bring the temperature to 330 F with the material under pressure and maintain the temperature about 30 min per 1/8-in. thickness. In this case the material must be cooled before it is removed from the mold. The first cycle is clearly the more practical.

The post-curing cycle which removes the products of the phenolic condensation reaction and results in a 20-25% increase in mechanical properties is also the subject of varying opinions. Depending on how "reliable" a laminate is desired, recommendations may range from 16 to 72 hr. at temperatures increasing to a maximum of 350 F or higher. One fairly short cycle that has been used consists of 15 hr at 250 F, 4 hr at 300 F, 4 hr at 340 F and 10 min at 390 F. A longer cycle is represented by 24 hr at 250 F, 12 hr at 300 F and 12 hr at 350 F. The post-curing cycle depends not only on the degree of reliability required but on considerations of operating economy.

Applications

Essentially a new material, phenolic-glass low pressure laminates have yet to be proved in many commercial applications. The nature of their fabrication cycle makes them unsuitable for parts produced in extremely large quantities. For large parts produced in relatively small quantities, where the characteristic advantages of reinforced plastics construction are applicable, this material offers elevated temperature properties not found in any other nonmetallic material at the present time. From an economic viewpoint, the possible savings in fabrication cost must be weighed against the generally higher materials cost.

Currently, this material is being evaluated in connection with two important fields of application: aircraft and guided missiles, and high temperature electrical insulation. There is no information available on electrical applications as GE's work in this field is still in the early development stage. Aircraft and guided missile applications are largely classified. It is believed by some that first use of the material in fuselage construction will most likely be in guided missiles rather than aircraft. Already the material has found use in ducts used to channel hot gases from aircraft engines to leading edges of wings for deicing. It has been used in a compressor stator case subject to a prolonged temperature of 500 F, and it has been used for jet engine compressor blades.

Table 2—Electrical Properties of Phenolic-Glass

	Laminate with 38% 12304 Resin	Laminate with 39% S-1072 Resin
Power Factor (as cured)	0.015	0.014
Dielectric Constant (as cured)	4.90	4.65
Power Factor (after 7 days at 480 F)	0.009	0.012
Dielectric Constant (after 7 days at 480 F)	3.75	3.89

Note: Tests run on 1/8 in. laminates pressed at 20–30 psi and 320-330 F for 1/2 hr and postcured 24 hr at 260 F. Glass cloth was 181-114.
Adapted from data provided by General Electric Co.

Acknowledgment

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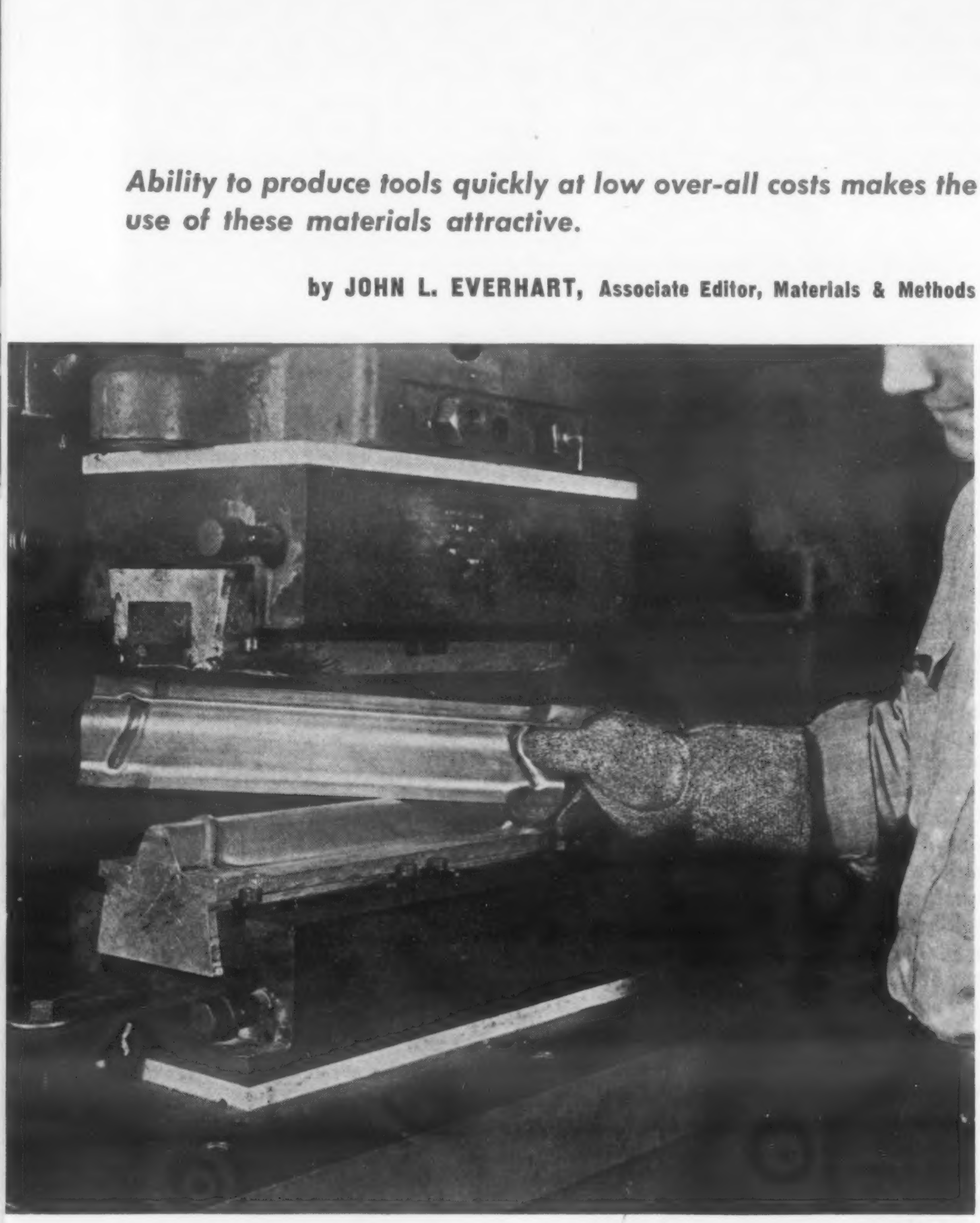
Die Materials

Ability to produce tools quickly at low over-all costs makes the use of these materials attractive.

by JOHN L. EVERHART, Associate Editor, Materials & Methods



Cast aluminum alloy punch and die sets are useful for producing parts where severe forming is not required.

ZINC-BASE ALLOYS

ANTIMONIAL LEAD
(6 to 7% Antimony)

BISMUTH-BASE ALLOYS

HARDWOOD (MAPLE)

DENSIFIED WOOD

RECONSTITUTED WOOD

CAST PHENOLIC PLASTICS

LAMINATED PLASTICS

● TOOLING REQUIREMENTS for forming operations vary with the number of pieces required. For extensive production runs, steels are used almost exclusively. For shorter runs, however, a number of other materials serve. Among such materials are zinc alloys, lead alloys, densified wood and plastics. For convenience, tools made of these materials can be called limited production tools.

The selection of a suitable material for limited production tooling is based on a number of factors. Possibly the most important is the severity of the forming operation required. Thus, zinc-base alloys can be used for the production of more complicated parts than densified wood. The required output is also a factor. Hardwood is suitable only for very short runs while cast plastics can be used for much greater output. The material to be formed and its thickness must also be considered, since some of the materials are suitable only for forming the light alloys in thin sections; others can be used to form heavier gage light alloys and some steels. In general, direct cost of the die material is of relatively minor importance, the overall cost of the finished tool being the important criterion.

The characteristics of some of the more common materials used for limited production tooling are given in an accompanying table. The air-

for Limited Production Runs

Typical Properties	Characteristics	Applications
Density, Lb/Cu In. 0.25 Melting Point, F 717 Compr Str (sand cast), Psi 60,000–75,000 Tens Str (sand cast), Psi 37,800 Tens Str (rolled), Psi 62,000 Brinell Hardness 100	Mechanical properties approach those of mild steel; good abrasion resistance; self-lubricating properties. Can be readily cast to size. Cast surface is dense and smooth and requires little finishing. Dies have been prepared in from 1 to 3 days compared with several weeks for equivalent steel dies. Has low melting point and can be remelted without large dross losses, thus permitting reuse of material.	Can be employed for blanking and drawing dies of more complicated shapes and for deeper draws than can be employed with wood or plastics. In Ceco-stamping or drop-hammer operations, one member of die-set is often zinc-base alloy, the other a softer material. Used on aluminum alloys of various gages, low carbon and some moderately alloyed steels, stainless steels and high nickel alloys, for moderate production runs.
Density, Lb/Cu In. 0.39 Melting Range, F 486–545 Tens Str (cast), Psi 7,000 Brinell Hardness 13	Flows rather than fractures, thus in preparing a punch, all minor surface irregularities removable by dropping punch into die. Punch can be cast quickly when used with zinc-base die by using latter as mold. Alloy can be remelted and reused.	Frequently used as punch in drop hammer operations with zinc-base alloy die for forming aluminum alloys, stainless steels, magnesium. Generally discarded after runs of 100 to 300 parts. On simple shapes can produce 300 stainless steel parts or about 1000 aluminum parts.
Density, Lb/Cu In. 0.34 0.34 Melting Range, F 217–440(a) 158(b) Tens Str (Cast), Psi 13,000 6,000 Brinell Hardness 19 9	(a) Hard alloy of bismuth, lead, tin and antimony. Can be cast to shape readily. Used for small die sets. (b) The eutectic alloy of bismuth, lead, tin and cadmium used often for large dies, melts at 158 F.	Used for short-run dies for aircraft parts often with one member of the die set rubber or lower melting bismuth-base alloy. Chilling in liquid nitrogen has been used to harden dies for operations on heavier gages of steel, experimentally.
Density, Lb/Cu In. 0.023 Max Crush. Str, Psi: Parallel to Grain 7,800 Perp. to Grain 1,800	Maple is hard, dense and close grained. Does not have tendency to splinter. Dies can be prepared quickly.	Blanking, forming or shallow drawing operations on thin gage aluminum. Applications are limited.
Density, Lb/Cu In. 0.048 Compr Str, Psi 22,000–27,000 Tens Str, Psi 15,000–40,000 Modulus of Rupture, Psi 20,000–46,000	Formed by impregnating hard wood veneer with phenolic resins, drying and compressing. Weighs about 1/6 as much as steel. Low coefficient of friction; shrinkage and warpage negligible. Estimated that densified wood can be prepared in 1/2 time required for metal dies. Tolerances cannot normally be held as close as with metal dies.	Forming and drawing dies for aluminum alloys. Short-run or moderate run dies depending on type of operation. Service life often extended by use of metal inserts.
Density, Lb/Cu In. 0.05 Tens Str, Psi 77,000 Mod of Rupture, Psi 12,500	Formed by exploding wood into ligno-cellulose and compressing to desired density. Can be readily laminated with cold-setting adhesives. Weighs approximately 1/6 as much as steel. Usually requires no lubrication and therefore not useful for impact-forming operations. Can be worked with wood-working tools and dies can be produced rapidly.	Used for bending and forming of thin-gage aluminum parts usually for short runs, although up to 5000 parts have been produced satisfactorily.
Density, Lb/Cu. In. 0.045 Compr Str, Psi 11,000 Rockwell Hardness R110	Most widely used material is a cold-pouring, thermosetting plastic which can be cured at temperatures of 140 F. Can be cast to form, has a high gloss finish, can be machined readily, easily repaired. Dies can be produced rapidly from this material, often by using a part as the mold to form the new die.	Blanking and forming dies for aluminum alloys and limited production on stainless steels and low carbon steels. Short-run or moderate run die depending on type of operation. Service life can be extended by use of metal inserts.
	Produced by binding glass fibers with polyester resins—molded to shape. Light weight, durable. Can be produced quickly.	Blanking and forming dies for aluminum alloys, low carbon and stainless steels. Short-run or moderate run dies depending on type of operation. Also used to patch cast phenolic dies. Service life can be extended by use of metal inserts.

NOTE: There is no significance in the order in which these materials are listed.

craft industry is probably the greatest user of these materials since most parts produced for airplanes are produced on a rather modest scale when compared with automobile parts, for example. The most widely used materials are zinc-base alloys, cast phenolic plastics and densified wood. In general, the zinc alloys, having characteristics approaching those of mild steel, can be used for more extended runs than the other materials and are suitable for dies of greater complexity. However, these materials are much heavier than either plastics or densified wood and the latter two are finding favor especially for forming large parts where the weight of a

Antimonial lead punches in combination with zinc alloy dies are frequently used for the hammer forging of aluminum alloys and stainless steels. These tools can be made quickly and cheaply by casting the zinc alloy into a plaster mold and using the zinc alloy die as a pattern for casting the lead alloy punch.

Reconstituted wood stretch form blocks are especially suitable for experimental or small lot production.

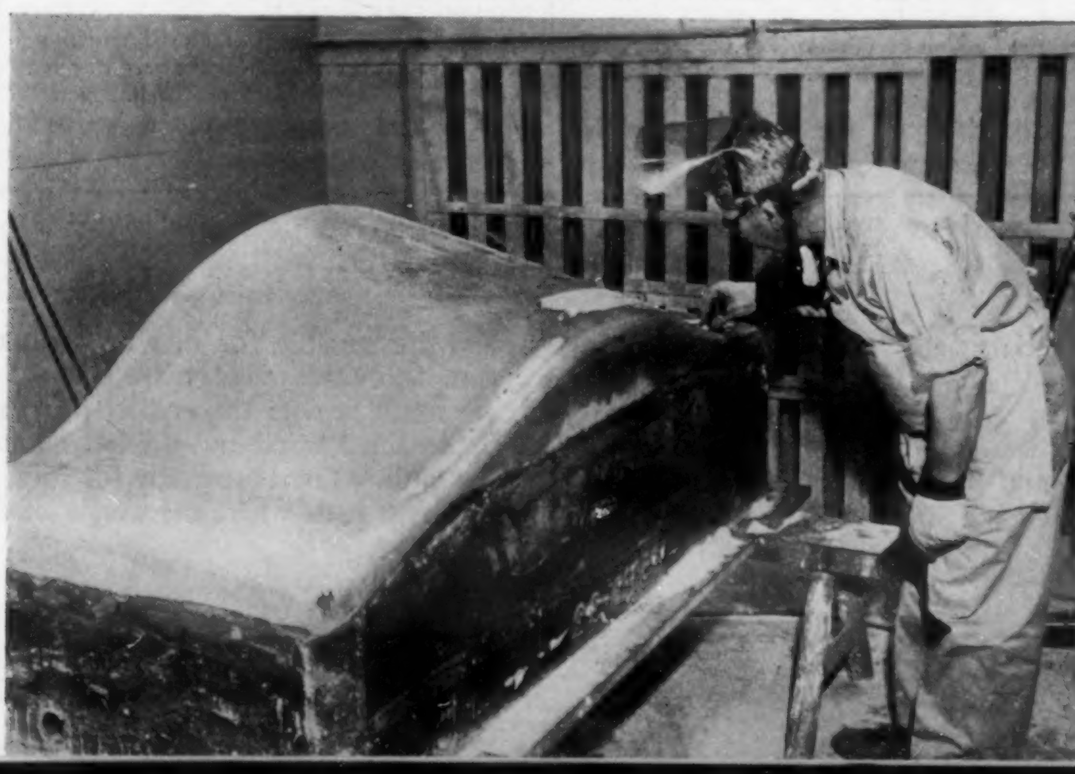
zinc alloy would introduce a handling problem.

Time Saved

One of the major advantages of all of these materials is the speed of fabrication. Dies can be produced from all of them in a fraction of the time required to prepare steel dies. Zinc, lead and bismuth-base alloys can be cast to form and require little finishing after casting. If the operations permit and the production runs are sufficiently short, time can be saved in making the die-set by casting the die from zinc alloy over a plaster mold and using the die as the mold for casting a punch out of lead alloy. Similarly, punch and die can be produced simultaneously from bismuth alloys by casting the metal on opposite sides of a finished part, which thus becomes the pattern. In using densified wood, the die can be machined from a built-up laminated section using ordinary wood-working tools and frequently can be completed in a day.

With the most widely used casting resin it is possible to use a finished part as the mold since the resin is poured at room temperature and is cured usually by heating overnight at 160 F. Dies can often be put into service within two days. In addition, dies can be produced quite quickly from laminated plastics. The material is molded into shape and held under pressure until curing is complete. Following this treatment the

Cast phenolic plastics double-action dies can be produced quickly and have the advantage of light weight, making large dies convenient to handle.



die is baked for approximately three days and is then ready for service.

The limitations on production runs with densified wood and plastics can be overcome to a considerable extent by using metal inserts at the points of greatest wear. Steel inserts have also been incorporated into the alloy dies for the same purpose.

Various savings have been reported by substituting one type of die material for another. Some developments in this direction are indicated by the following case histories.

Some Cost Comparisons

Draw die punch—Original material cast phenolic requiring about 318 hr fabricating time. Changed to densified wood at a saving of 33 man hr in fabricating time, a large increase in the percentage of acceptable parts produced and in tool life and a saving of $300 in material costs.

Draw dies — Original material wood; labor and material costs $260. Changed to densified wood; labor and material costs $504. However, savings in parts formed and great increase in tool life made densified wood tools cheaper than wood.

Blanking die—Originally made of steel at a cost of $1000. Changed to zinc alloy at a cost of $200 and a reduction in die making time of 40%.

Forming die—Originally made of zinc alloy. Changed to cast plastic at a saving of ½ the cost and a reduction of 65 days in die making time. If this die had been made of steel it would have cost more than three times as much as the plastics and would have been 4500 lb heavier.

Skin stretcher die — Originally made of zinc alloy. Changed to cast phenolic plastic with a labor saving of 54 man hr and a reduction in cost of $104.

Skin stretcher die — Originally made of zinc alloy. Changed to cast phenolic plastic with a labor saving of 65 man hr and a reduction in cost of $118.

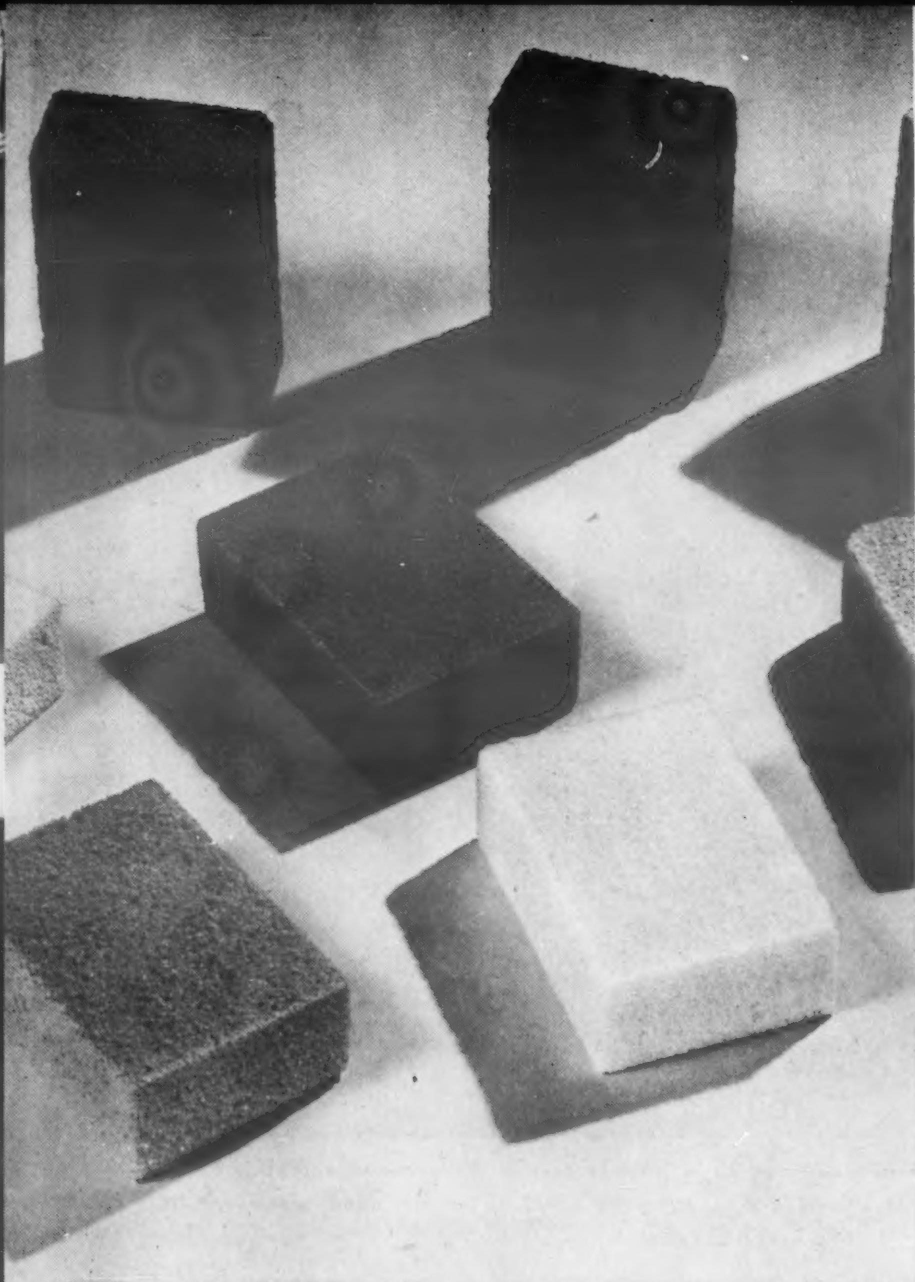
Propeller blade die — Originally steel. Replaced by zinc alloy with cost and time savings estimated at 75%. Although used on experimental basis results indicated that this die could be used for limited production.

Forming die—Used for fabricating parts from 20 gage cold rolled steel. Produced from laminated plastics at a cost of $450. Quotation for steel punch and die $4000.

Densified wood dies for the production of a nacelle section from aluminum alloy. This die which is 62 in. by 42 in. by 16 in. required 1600 lb of densified wood for its fabrication.

Bismuth-base alloys can be used for the production of large dies. The punch above weighs 12,000 lb and the die 10,000 lb.

PICTURE CREDITS: Boeing Airplane Co.; Cerro De Pasco Corp.; Forest Products Lab., U. S. Dept. of Agriculture; Lockheed Aircraft Corp.



Two new silicone resins, developed as castable foamed plastics may be dyed almost any color by adding pigments to the mix before blowing.

Liquid mix of XR-544 Resin is poured over silicone-glass laminate in a heated form, another sheet is added, and the resin foamed in place to form a light-weight sandwich structure.

New Silicone Resin — Foamed in Place —

NEW MATERIALS PREVIEW

● FOAMED PLASTICS, a relatively new development in the plastics field, have found a multitude of uses for thermal insulation, shock resistance, and light weight structural applications. Just recently there has been an increase in interest in this material due to the development by several companies of castable foamed plastics. With the castable types, the resin plus a catalyst is poured into the mold or form and allowed to expand, conforming to the shape desired. Heretofore, the plastic material used in these castable foams has been limited mainly to phenolics or isocyanate or urea formaldehyde base resins, all of which are thermosetting resins which will char in the presence of an open flame, though

Typical Properties of the Foamed Silicone Resins

	XR-543	XR-544
Density, Lb/Cu Ft	10–14	8–24
Cell Size, In.	Less than 0.008	Less than 0.008
Compressive Str, Psi:		
@ 77 F	100–250	500–800 (Density of sample: 18–20 lb/cu ft)
@ 500 F	15–30	(After ½ hr) 100–240
@ 500 F		(After 200 hr) 90–240
@ 700 F		(After ½ hr) 50
Weight Loss, %:		
After 220 hr at 480 F	0.41	0.15
After 220 hr at 570 F	1.71	0.52
Moisture Absorption, %:		
After 7 days at 96% Rel. Humidity	Less than 0.05	0.032
Heat Distortion Temp., F	Greater than 700	Greater than 700
Flame Resistance	Will not burn	Will not burn
Dielectric Constant at 10^5 cycles	1.18	1.4
Power Factor at 10^5 cycles	0.0005	0.00027

One side of ½-in. silicone foam block is heated to a cherry red while the other side is only warm to touch.

Is High Temperature Insulator

they will not support combustion.

The development of two new silicone resins for castable foamed plastics by the Dow Corning Corp. promises to add new versatility of application to this still relatively limited field. Probably the most important contribution these two resins will make is in applications for thermal insulation. Foams made of these resins have been exposed to temperatures of 700 F for over 20 hr with very little structural or dimensional change. Sections only ½ in. thick can be brought to a red heat over an open flame without showing significant decomposition, and only a slight warmth can be felt on the opposite side. Both these resins, XR-543 and XR-544, are now available in limited quantity for development research.

Properties

Though the foamed XR-543 resin can be subjected to temperatures of 700 F with negligible structural or dimensional change, at 500 F it becomes resilient and loses a considerable amount of its compressive strength without noticeable change in structure or appearance. This thermoplastic characteristic can be applied to advantage in forming foamed resin to the desired shape before the final cure.

The properties of XR-543 resin make it particularly adaptable for use where extreme temperature resistance is required, but high compressive strength is not essential. Such applications include vibration damping, electrical, acoustical and thermal insulation, and buoyancy units.

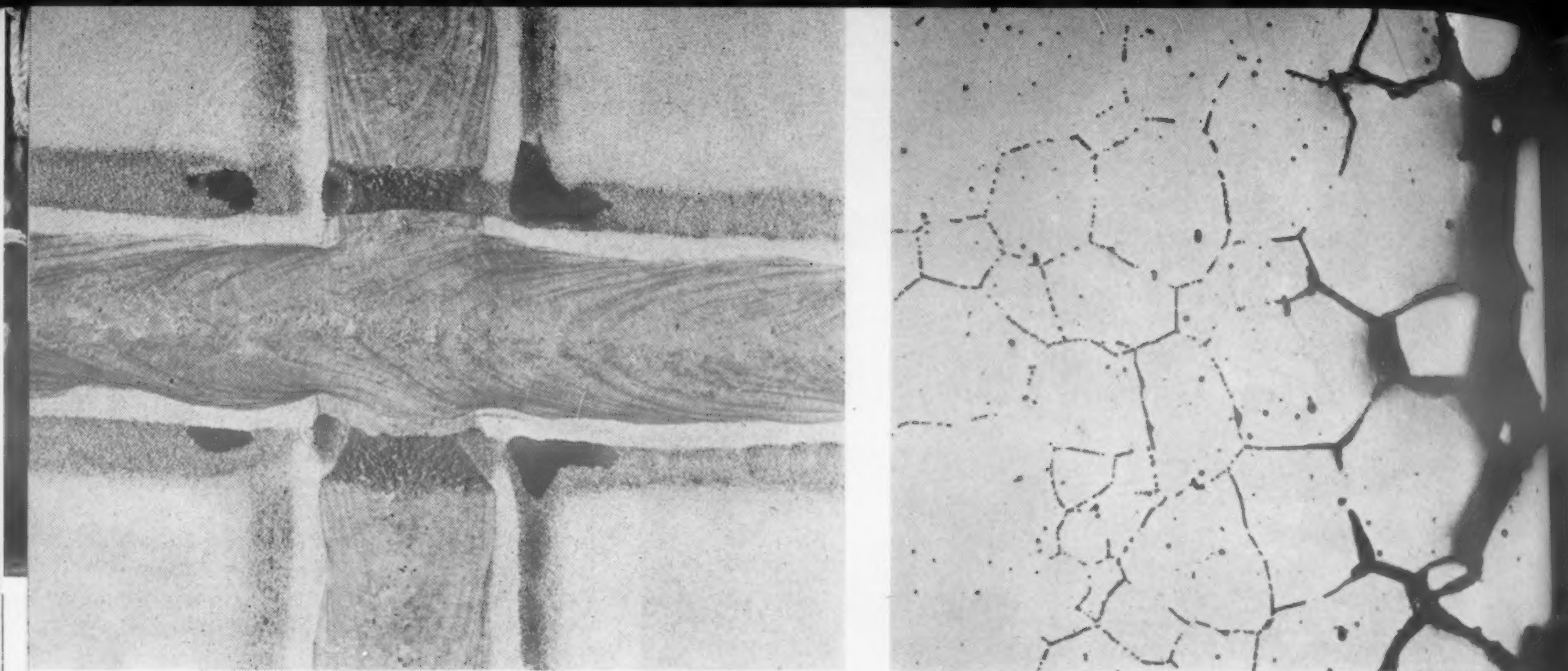
A rigid, thermosetting silicone resin with good compression strength, XR-544 resin foamed, retains a high ratio of its initial strength, even at temperatures in the range of 500 F. It will give durable service at temperatures where foamed organic resins fail in a relatively short time. It is highly resistant to extreme temperatures having been heated to red heat without noticeable decomposition.

The properties of this resin suggest its use in fire wall structures; various types of thermal, electrical and acoustical insulation where its structural strength may be utilized; and sandwich construction, produced by foaming in place.

Expansion and Forming

Both resins, are supplied as clear, brittle, 100% solids. The XR-544 readily melts in a heat range of 250-290 F, while XR-543 requires a range of 280-300 F. After melting they can be stirred with a mechanical mixer while adding the blowing agent and catalyst. The molten mixture is then transferred to the container to be filled, and heated to produce the foamed shape. In the case of XR-544, a temperature of 300 F produces a foam density of 10-12 lb per cu ft, while 285 F results in a foam density of 18-20 lb per cu ft. With the XR-543, 300 F produces a density of 14-18 lb per cu ft, while 320 F is necessary to give 10-12 lb per cu ft. In both cases, after the required time, the temperature is then gradually raised and the foamed resin given the final cure. The by-products evolved from processing are not toxic, but ventilation should be provided.

As well as foamed in place, these resins can be cast in blocks or sheets, or made up as sandwich structures. Either resin produces a uniform, multi-pore foam structure, with unicellular and spherical pores. After proper curing the foams can be carved or cut to almost any desired shape with conventional wood working tools. Both resins are said to have good shelf life, samples having been stored for nine months at room temperature without noticeable change in the processing characteristics of the material.



1 INTERGRANULAR CORROSION results from carbide precipitation in weld heat affected zones. Left: typical attack by nitric-hydrofluoric acid in Type 304 base metal and Type 308 weld. (Original magnification 3-½ X). Right: photomicrograph shows how corrosion in carbide-laden boundaries detaches whole grains from surface. (Original magnification 250X).

How To Control Carbide Precipitation

by G. E. LINNERT, Research Welding Metallurgist and

R. M. LARRIMORE, JR. Assistant Research Engineer, Research Laboratories, Armco Steel Corp.

When welding austenitic stainless, proper steps must be taken to prevent sensitization which can lead to intergranular corrosion. There are three reliable methods. Others, sometimes used, are at best only partly effective.

● FABRICATORS OF AUSTENITIC grades of stainless steels are well aware of the damage by intergranular corrosion resulting from carbide precipitation or "sensitization" near welded joints, and are eager to learn how to deal with this corrosion threat in the most economical and effective manner. This article, therefore, will attempt to fill the need for information which summarizes the practical methods of controlling carbide precipitation.

What Is Carbide Precipitation?

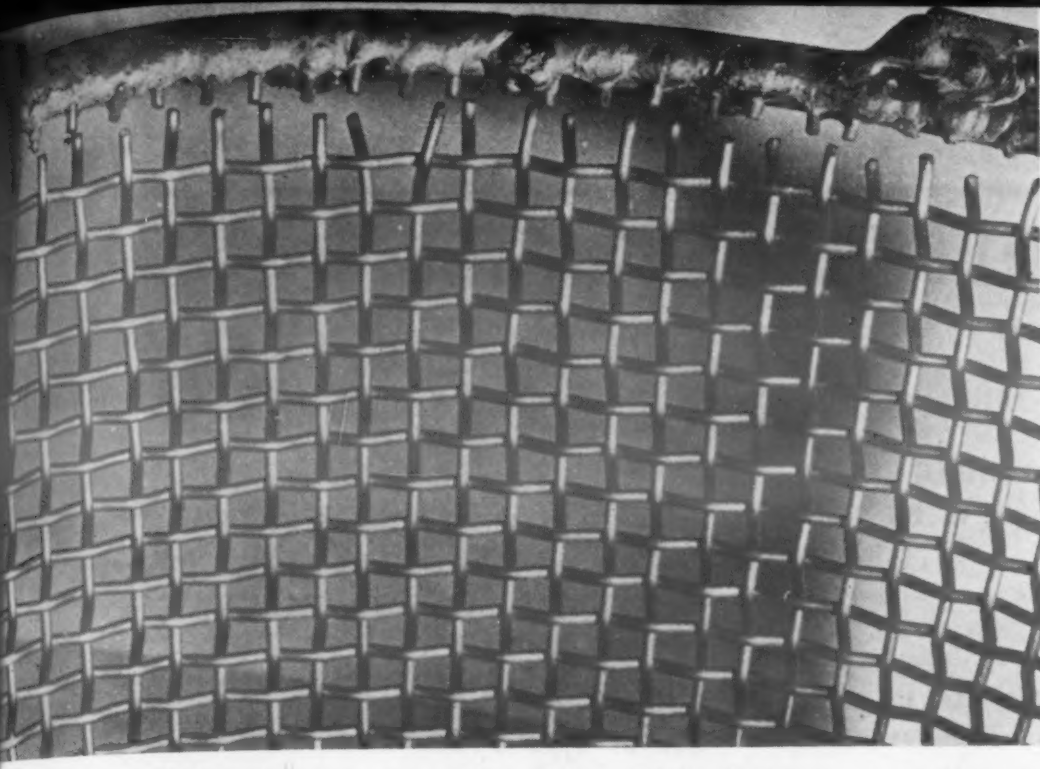
Intergranular carbide precipitation results when austenitic stainless steels are exposed to temperatures in the range of 800 to 1600 F. In this sensitizing temperature range, carbon migrates to the grain boundaries and precipitates there as chromium carbide particles. The removal of valuable chromium immediately adjacent to the boundaries causes this area to become deficient in the chromium needed to maintain corrosion resistance. Also, the chromium carbide particles create a galvanic couple with the surrounding metal and give further impetus to corrosion in the chromium-depleted area.

While intergranular carbide precipitation is generally regarded as taking place over the temperature range of 800 to 1600 F, the rapid heating and cooling that accompany welding restricts sensitization to a somewhat narrower temperature range. As can be seen in the photograph (Fig 1) the sensitized zone or band is not immediately adjacent to the weld, but is located about ⅛ in. away. The base metal immediately adjacent to the weld is annealed by the heat of welding, and the cooling rate is usually rapid enough to hold the carbon in solution.

When examining a weld joint in which intergranular corrosion has taken place, the appearance of the surface alone is not always a true indication of the severity of attack because the depth of intergranular penetration may be far greater than the loss of metal at the surface. The fact that the damage occurs over a relatively small area is also important to remember. If corrosion tests on welded specimens are to be helpful, they must go beyond the customary weight-loss measurements and include the results of a microscopic examination of heat-affected zones near the weld joints (Fig 1).

Methods of Avoiding Sensitization

The engineer sometimes is tempted to take a short cut or to use a makeshift measure to control sensitization in a welded article. However, there are only three dependable methods available for positive control of sensitization: 1) post-weld solution annealing treatment, 2) stabilization of the carbon with strong carbide-forming elements like columbium, tan-



2 *CORROSION FAILURE in this Type 304 stainless pickling basket was caused by vertical wires corroding in zones sensitized by metal-arc weld bead.*

in Welding Stainless Steels

talum, or titanium, and 3) use of a stainless steel having an extra-low carbon content.

Each method has certain limitations. Therefore, the selection will depend on many factors, such as size of the weldment and availability of suitable equipment for heat treating and descaling, the current supply of material in regular, stabilized, or extra-low-carbon grades in the size and quantity needed, and the service conditions under which the weldment will operate.

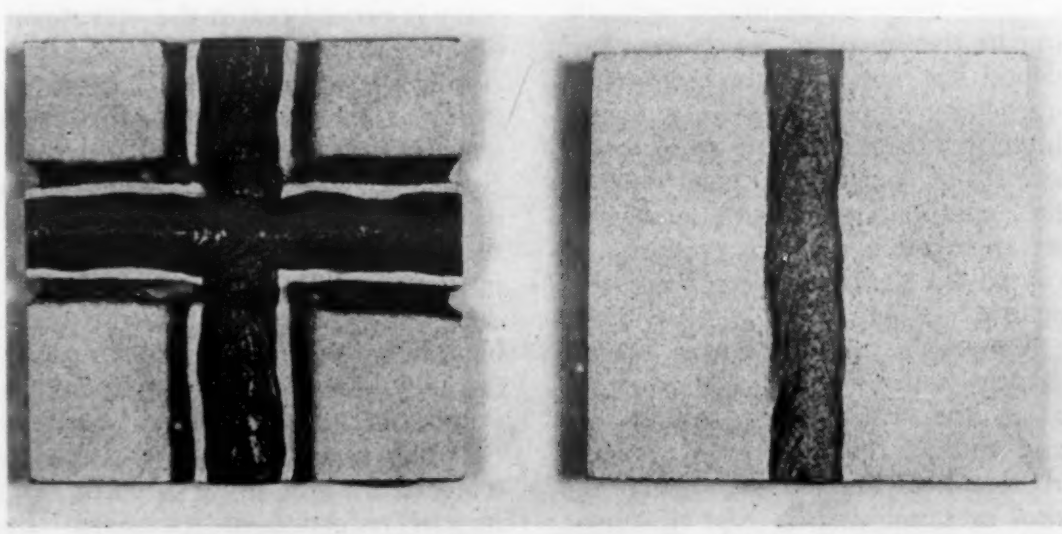
Post Heat Treatment—Heat treatment after welding is the oldest means of avoiding intergranular corrosion in the sensitized zones of welded austenitic stainless steels. Customary treatment consists of a "solution" anneal which involves heating the weldment to a temperature high enough to dissolve any intergranular carbides and to restore vital chromium to depleted boundary areas.

This operation is carried out in the temperature range of 1850 to 2050 F. The optimum temperature depends on the grade, while soaking time is determined by the section. Short time at temperature is preferred to avoid grain growth, and a rough rule is to soak the material at temperature three minutes for every one-tenth inch of thickness to insure solution of the carbides. The weldment must be cooled rapidly at least through the temperature range of approximately 1650 F down to 800 F, in order to retain the carbon in solid solution. Water quenching or water spraying is necessary for heavy sections and air cooling is permissible only for very light sections (Fig 3).

Disadvantages of the annealing treatment are high temperatures required, distortion that occurs in heating, and the problems associated with the quenching operation. When an oxidizing atmosphere is employed during heating and cooling, the surfaces must be descaled by pickling, sandblasting, or some other suitable process. Annealing is often impractical because the finished weldment is too large for available annealing furnaces. The likelihood of making repairs or alterations by torch cutting and welding after the equipment has been in service should be considered since placing the entire unit in a furnace may not be possible and locally annealing newly welded areas produces sensitization in the area of the temperature gradient.

Use of an annealing treatment sometimes is dictated by other circumstances. Stresses which invarably arise in any welded structure frequently have been singled out as reason for annealing. However, the need for a stress-relief treatment in weldments constructed of austenitic stainless steel has been over-emphasized. In taking stock of the situation recently, the record of vessels in the as-welded condition was good; whereas a number of cases had arisen, usually in heavy wall vessels, where a post heat treatment had induced serious cracking near the weld joints of the vessels. Therefore, the latest edition of the ASME Rules for Unfired Pressure Vessels (Section VIII, Part UHA, 1952) has omitted mandatory requirements for stress-relief.

The chance of stress-corrosion cracking is another reason for post-heat treatment. Austenitic stainless steels, like many other commonly used metals, are susceptible to stress-corrosion cracking in certain media, and it is difficult to predict when an environment will produce this defect and to decide how much reduction must be made in the magnitude of residual stress to avoid its occurrence. Customary practice with welded austenitic grades of regular



3 *SOLUTION ANNEALING TREATMENT of plate (right) prevents carbide precipitation that occurred in as-welded specimen (left). Specimens are metal arc welded Type 304, carbon content 0.064%, 0.125 in. thick. (Nitric-hydrofluoric acid etch test.)*

CARBIDE PRECIPITATION

These Factors Affect It:-

Thickness of Base Metal

Thin gages more prone to sensitization since heat input is likely to be relatively heavy.

Welding Process

Sensitization varies with heat input of process. Arc applied directly to work can accomplish weld with less heat input than atomic-hydrogen arc, or oxyacetylene methods.

Welding Rate

Speed of welding also controls heat input per linear inch of seam. Fast rate of travel decreases sensitization.

Heat Input

Sensitization is minimized by welding with lowest possible heat input per linear inch. Increasing travel speed is best means of reducing heat input.

Cooling Rate

Sensitization is minimized by rapidly removing heat from base metal zone simultaneous with the welding operation. Although some steps can be taken to minimize sensitization, such as by using chill bars or water quenching, they do not eliminate it.

These Methods Can Control It:-

Post Annealing (Limitations)

Annealing 1850-2050 F imposes problems with distortion, scaling, rapid cooling. Quenching large vessels difficult; may introduce harmful stresses. Field alterations by torch cutting and welding may be risky.

Use of Type 347

Columbium-tantalum steels restricted to defense use. Weldments may display "knifeline attack".

Use of Type 321

Titanium containing grade sometimes not suitable because of finishing or polishing characteristics. Weldments may display "knifeline attack".

Use of ELC Steels

Not recommended for weldments exposed to 800-1600 F service temperature for extended period of time.

Welding Technique

Fusion weld heat affects base metal. Sensitization occurs during both heating and cooling. Cooling rate determined by heat input, available coolng mass and media. Accelerated cooling shortly after welding does not significantly reduce sensitization.

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carbon content has been to post-anneal at 1850 to 2050 F to remove the residual stress, since treatment at a lower temperature might seriously impair the corrosion resistance. Evidence has appeared, however, that quenching or rapidly cooling from a high temperature can create new stresses of considerable magnitude in the annealed weldment, and that stress-corrosion cracking can be caused by stresses arising from this source.

Obviously the fabricator would greatly prefer a post-heat treatment at a somewhat lower temperature and without requiring rapid cooling. A treatment termed stabilizing anneal or immunization heat treatment has been applied on occasions to the regular chromium-nickel and chromium-nickel-molybdenum steels for the purpose of reducing residual stresses and for nullifying the effect of intergranular carbides. The treatment is carried out in the upper part of the temperature range in which carbides precipitate, that is, approximately 1300 to 1600 F. However, temperatures between 1500 and 1600 F generally are employed. The weldment is soaked at temperature for a substantial period of time with the intent of diffusing chromium into depleted areas adjacent to the grain boundaries and for coagulating the carbides. Rate of cooling following immunization can be slow if desired.

While exposure to this range of temperature will bring about a substantial reduction of stresses in the weldment, the treatment is not often applied to materials of regular carbon content because the corrosion resistance does not compare favorably with the solution annealed condition. The ASME Rules for Unfired Pressure Vessels (as interpreted in Case 897, (3) (c)) allows the use of a stress relieving temperature of 1300 F and higher, but includes cautionary notes in the appendix regarding the lower temperature treatments.

Stabilized Grades—The elements columbium, tantalum, and titanium have a stronger affinity for carbon than chromium; therefore, if these elements are present in austenitic stainless steels, they will be precipitated in preference to chromium carbides in the austenitic matrix. The standard Type 347 grade originally contained columbium to the extent of at least 10 X C. Type 321 grade contains titanium to the extent of 5 X C minimum, and although the

material has certain shortcomings, it is generally regarded as a satisfactory alternate for the Type 347 grades in most cases. Type 316 is regarded by some engineers to be immune to weld sensitization, but data to be presented later in this article show that molybdenum should not be considered a satisfactory carbide stabilizer (Fig 4).

A stabilized grade is required when an article will operate at a temperature within the sensitizing range of 800 to 1500 F and will also be exposed to corrosive conditions. The greater strength of these steels at elevated temperatures is sometimes an advantage. If the article is welded, the weld deposit may be stabilized with columbium or titanium. The latter element can be efficiently transferred only with one of the gas-shielded arc processes. Exposure to the heat of welding alone is hardly enough justification for using a columbium stabilized steel, because the matter of weld sensitization can be handled by post annealing, or through the application of Type 321, or with an extra-low-carbon grade.

One misconception is that a columbium-bearing electrode will eliminate sensitization in the heat-affected zones of regular unstabilized grades of base metal. This is not true because the area of failure due to weld sensitization is in the base metal and no diffusion of columbium from weld to sensitized base metal takes place.

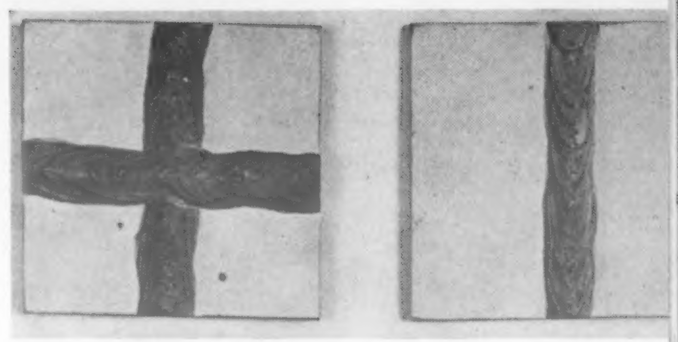
Use of stabilized stainless steels in weldments is not entirely free from difficulty with respect to sensitization. Corrosive attack in very narrow base metal zones immediately adjacent to the weld has given some chemical companies cause for concern. This condition has been termed "knifeline attack", and results from a characteristic of the stabilized grades not generally recognized. In a very narrow zone on each side of the weld, the base metal is heated to a temperature high enough to largely dissolve the columbium, tantalum, or titanium carbides. If these zones subsequently are reheated to the vicinity of 1200 F, at which temperature the solubility of columbium, tantalum, titanium, and chromium carbides are very low, chromium carbides will preferentially precipitate in the grain boundaries because of the greater amount of this element in the alloy. The zones thereby become sensitized and, of course, are susceptible to intergranular attack. However, if the zones after welding are reheated to a higher temperature in the vicinity of 1600 F, columbium, tantalum and titanium carbides will precipitate in preference to chromium carbides because their solubility is lower than that of the chromium carbides.

This form of precipitation takes place intra- and inter-granularly without harming the corrosion resistance of the material. If the joint is first reheated to the vicinity of 1600 F, the stabilized form of carbide is precipitated and later exposure at 1200 F will not sensitize the adjacent base metal zones. Type 321 is more susceptible to knifeline sensitization than Type 347 because titanium carbides are dissolved at a lower temperature. Hence, a wider solution-treated zone is created on each side of the weld.

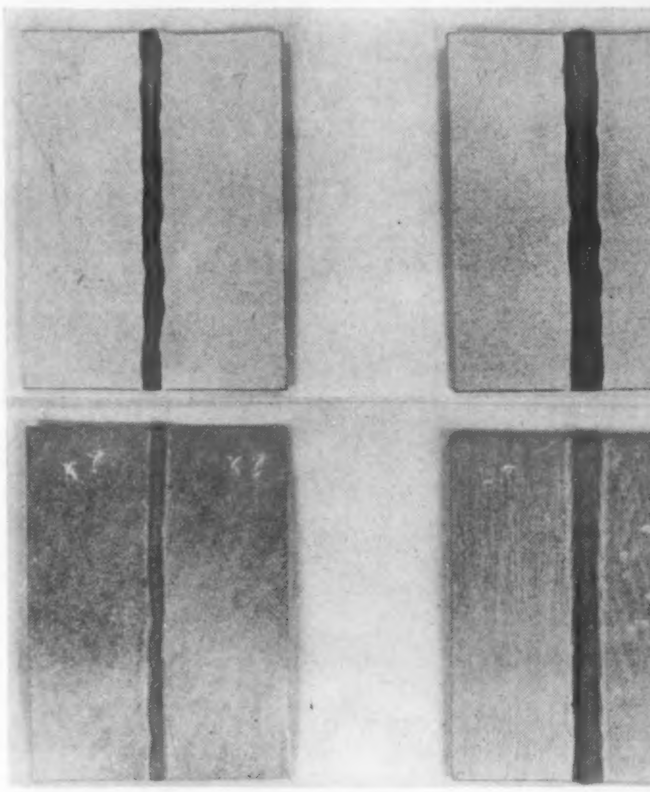
Extra-Low-Carbon Grades — The use of extra-low-carbon austenitic stainless steels is the newer means of avoiding harmful carbide precipitation in welding and in stress-relief heat treatment. In these materials a maximum carbon content of 0.03% insures enough immunity to precipitation in the 800 to 1600 F temperature range to withstand any normal welding or stress relieving operations without danger of impairing the materials' corrosion resistance (Fig 5). Because carbides will precipitate in significant quantities in these 0.03% maximum carbon materials, when held for an extended period of time in the 800 to 1600 F temperature range, their use is recommended at service temperatures below 800 F.

The ELC (extra-low-carbon) grades are being produced in all forms in large tonnages. They are covered by the standard specifications of most bureaus, societies and code-writing bodies. The AISI designates the extra-low-carbon grades by the suffix "L", and has included Types 304L and 316L in the list of standard steels. The ASME Rules interpret their use under Case 1122-2.

In welding the ELC grades, no new problems are presented in selecting an applicable process and welding procedure. The weld metal may be an ELC composition or it may be stabilized with columbium or titanium, depending upon the process employed. For oxyacetylene welding, the slight carburizing action of the usual welding flame makes the use of Type 347 filler rod necessary on ELC base metal. Covered electrodes for metal-arc welding are commercially available in Types 308L and 316L, although the columbium stabilized



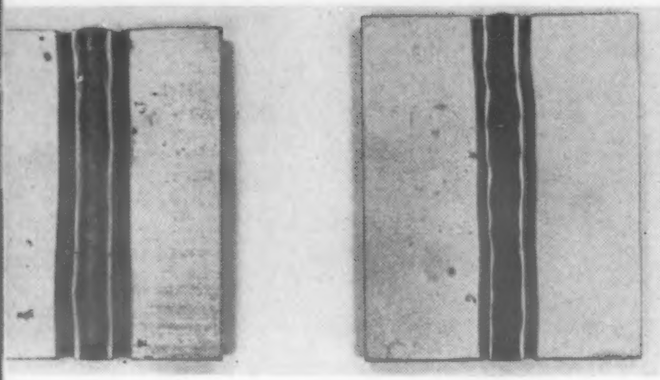
4 ***STABILIZED GRADES** containing columbium, tantalum or titanium prevent carbide precipitation. Shown here is a columbium stabilized Type 347, 0.125 in. thick, in as-welded (left) and 1600 F stress-relieved conditions (right). (Nitric-hydrofluoric acid etch test).*



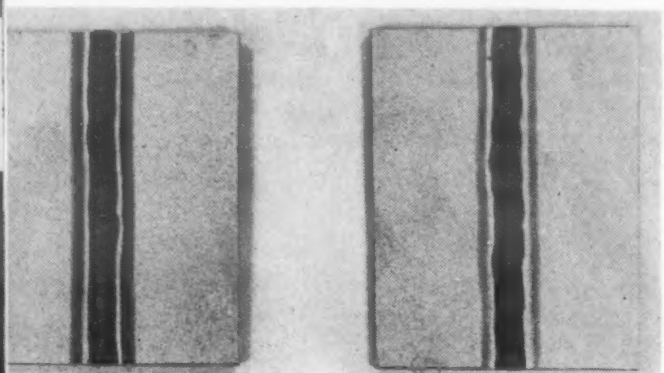
5 ***EXTRA-LOW CARBON GRADES** show no evidence of carbide precipitation when arc welded specimens are subject to nitric-hydrofluoric acid test. Top two samples, Type 304L (0.026% C); bottom samples, Type 316L (0.023 and 0.024% C).*

counterpart grades may be employed. Since the inert-gas-shielded arc processes offer no problems with carbon pick-up or alloy loss by oxidation, filler rod or bare electrode wire of the ELC grades and the columbium and titanium stabilized grades are satisfactory for the tungsten-arc or metal-arc methods.

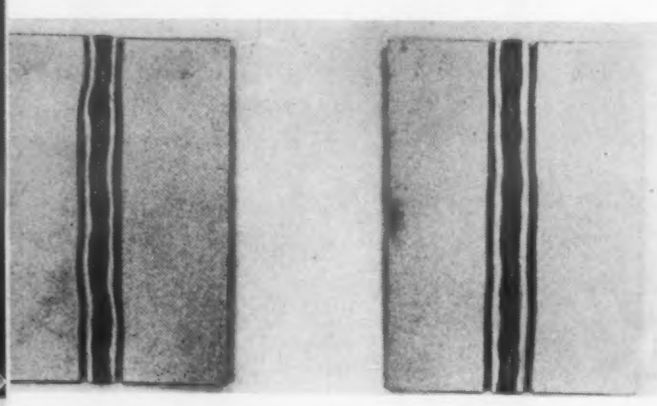
The ELC grades may be stress-relieved at temperatures below the customary annealing range without jeopardizing the corrosion resistance of the material. Rapid cooling is not needed to hold the very small amount of carbon in solution in the steel, which avoids the possibility of quenching stresses causing stress-corrosion cracking later in service.



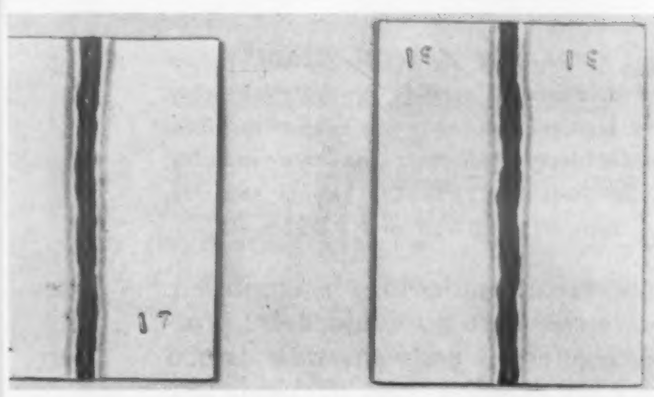
Type 302, 0.089% C, 0.125 in. thick



Type 304, 0.062% C, 0.125 in. thick



Type 304, 0.079% C, 0.061 in. thick



Type 316, 0.069% C, 0.067 in. thick

NORMAL PRACTICE — CONTINUOUS QUENCH (1-IN. DISTANCE)

6 ***POST-WELD QUENCHING cannot be depended on to prevent carbide precipitation. Nitric acid-hydrofluoric acid tests on quenched (right) specimens show little benefit from water quenching immediately after welding.***

Influence of Welding Technique

It has been proposed that the welding procedure or technique can be arranged to effectively control sensitization in the unstabilized regular carbon-content grades, such as Types 302, 304 and 316. Because carbide precipitation is time-temperature dependent, various methods of accelerating the cooling of the weld area have been advocated. These are claimed to prevent serious sensitization in both the weld metal and heat-affected base metal.

Considering that no supporting test data have appeared in the literature to show benefits to be gained from weld quenching, a series of welded specimens was prepared and corrosion-tested in the Armco Research Laboratories to determine the efficacy of several techniques. The manual metal-arc process using covered stainless steel electrodes was used to deposit weld metal on a number of grades and thicknesses of base material. All welding was carried out under conditions of current, travel, speed, and so forth, typical of regular shop practice. After preparing a first specimen in each material by normal practice, to serve as a standard or reference sample, three weld-quenched specimens were prepared using 1) a stream of water continuously directed behind the weld crater, 2) a large swab of water-soaked waste applied to the joint after welding, and 3) a quench by flowing water over the specimen after welding.

In preliminary experiments, the closest distance that the quenching stream could approach the weld crater without affecting the arc or causing porosity was approximately one inch. Guiding the stream at this point required extreme care by a helper. However, any distance greater than 1 in. was shown by these initial tests to be completely ineffective in suppressing sensitization. Use of a full quench or application of a wet swab after depositing a 6-in. length of weld bead were also without affect on the degree of sensitization.

Even though the use of a water stream 1 in. behind the welding arc might be considered impractical to include in regular shop practice, the continuous weld quenching experiments were carried out to determine by further etch tests the usefulness of controlling sensitization by this method in several grades and gages.

Accompanying photographs (Fig 6) show welded sections after exposure to a standard etch test consisting of three 4-hr periods in a 10% nitric-3% hydrofluoric acid solution at 175 F. This solution vigorously attacks sensitized areas. A comparison of the normal and the continuously-quenched weld specimens will show that very little, if any, benefit is achieved by rapid cooling the heat-affected zones after welding.

In comparing the two thicknesses of Type 304 material in the figures it would be well to recall that some engineers believe thin gages are not sensitized because they cool more rapidly than heavy sections. This is a misunderstanding of the welding conditions. Rate of cooling in the base metal heat-affected zone is determined by heat input along the joint and the mass of metal or other material available to take heat from this zone. A far greater part of the heat is conducted into the cold base metal and any clamping bars close to the weld area, while only a small amount of heat is lost to the atmosphere. Thin gages of material are apt to be welded with a higher heat input per linear inch than heavy sections, and unless chill bars are clamped in very close proximity to the weld, or a cooling medium held in contact with the area being welded, the cooling rate therefore will be slower.

Many of the misexplanations of weld sensitization and means for its control apparently arise because the location of corrosive attack on a tested sample or a failed weldment is not recognized as the result of a moving, localized heat source. This point will not be treated in detail here, but a brief explanation of where and when carbide precipitation takes place in welding should be helpful.

After exposure to a corrosive medium like the nitric-hydrofluoric acid solution, a sensitized weld joint displays a narrow parallel corroded zone in the base metal a short distance away from each side of the weld, while the zone adjacent to the weld does not suffer attack. An explanation of this pattern is often over-simplified by stating that heat flowing from the weld metal has raised the temperature of the adjacent zone into the solution annealing range, while the narrow zone beyond this has been heated into the carbide precipitation range of

roughly 1600 F down to 800 F. While this description of the thermal cycle seems to account for the annealed and sensitized zones, it permits a false assumption as to the benefit obtained from accelerating the cooling of the joint a short time *after* the weld has been made.

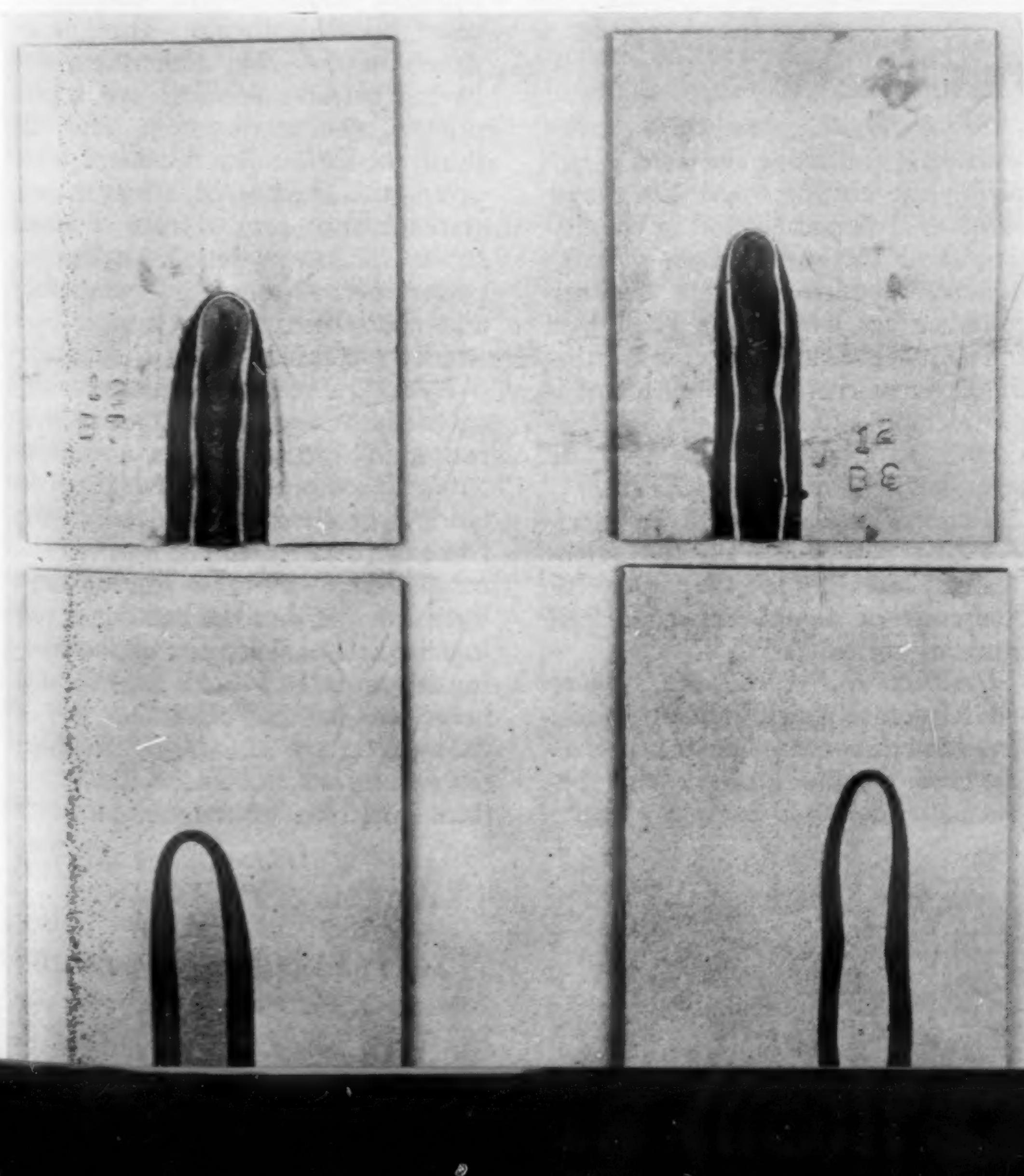
Figure 7 shows the stopping end of two arc-weld beads deposited on $1/8$ in. thick Type 302 (0.089% carbon) sheet. These test specimens were then exposed to the nitric-hydrofluoric acid etch test to reveal the sensitized zones. One bead was permitted to cool in a normal manner, while the other was drastically quenched to extinguish the arc and to quickly cool the metal surrounding the crater. If the entire length of each weld bead were deposited at one time, the simple explanation of sensitization would suffice. However, the bead and its attendant heat-effects are progressive and the final pattern of annealing and sensitization which appears along the weld joint must be interpreted in terms of a moving rather than a stationary heat source. A study of the specimens in Figure 7 will show that sensitization obviously starts to take place during heating ahead of the arc crater and increases in severity beside the crater. At a distance approximately 1 in. *behind* the crater, sensitization has almost reached completion for these particular welding conditions. Accelerating the cooling from this point backward can minimize sensitization only to a minor extent. Note that the metal immediately adjacent to the weld is first sensitized and then reannealed, and that the normal cooling rate is fast enough to retain the carbon in solution in this zone.

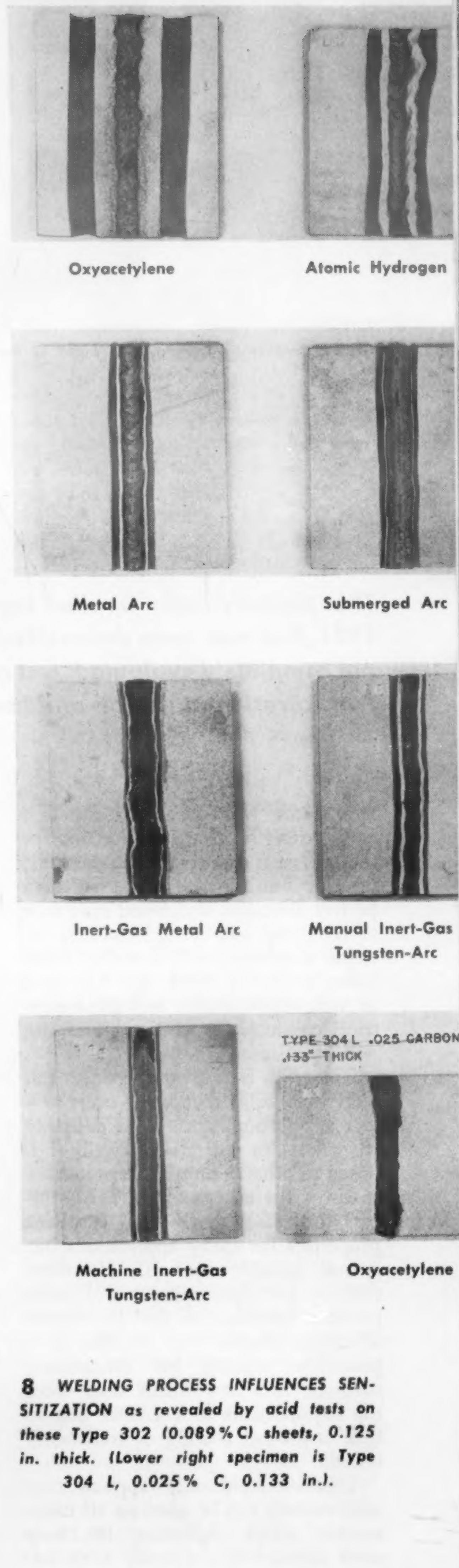
Influence of Welding Process

Figure 8 illustrates how the degree of sensitization can vary with the welding process. Heat input and the accompanying sensitization varies considerably with the various welding processes. Oxyacetylene welding, with its relatively low-temperature heat source and slow travel speed, produced the greatest amount of sensitization. The electric-arc permitted a marked reduction in the heat input per linear inch of weld and consequently produced less sensitization. Mechanized fast travel speed and an arc-welding process are the most important means of minimizing sensitization during fusion welding.

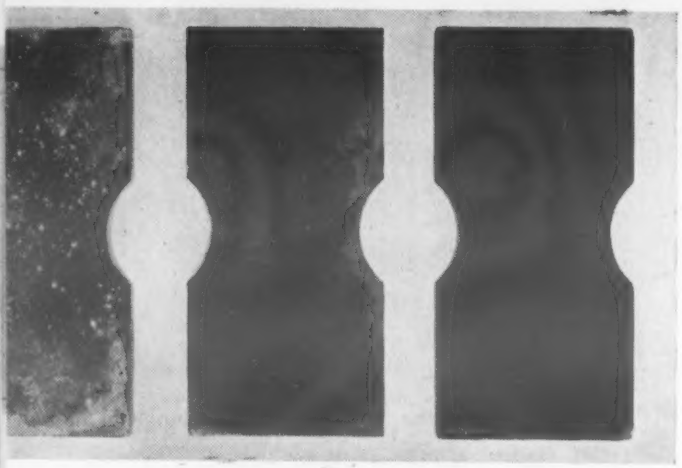
Here again the fabricator may be tempted to overcome the sensitization problems by using a fusion welding process that produces the least amount of sensitization by reason of its fast travel speed, but it must be remembered that the only methods of completely eliminating sensitization are post-annealing, use of stabilized grades, or the use of extra-low carbon compositions.

7 *FAILURE OF POST WELD QUENCHING is illustrated by acid tests on stopping-end of arc weld beads. Top shows face side of specimen; bottom shows back side. On left are normal practice weld beads; on right beads instantaneously quenched after welding.*

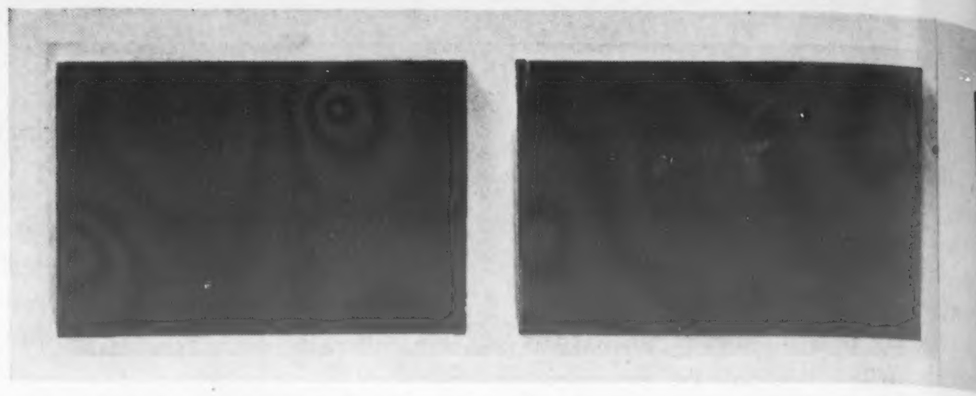




8 *WELDING PROCESS INFLUENCES SENSITIZATION as revealed by acid tests on these Type 302 (0.089% C) sheets, 0.125 in. thick. (Lower right specimen is Type 304 L, 0.025% C, 0.133 in.).*



Left to right, plain, dichromated and HAE coated magnesium panels after 1000 hr water immersion.



HAE coating on panels before (left) and after (center and right) being subjected to heat of two blast burners. Right is cross section of heated panel.

These Tests Show Excellent Properties of

This electrolytically applied ceramic coating, developed in 1951, has now been declassified by the military. Though still not completely evaluated, test results show it to have excellent corrosion, abrasion and heat resistance.

● HUMAN NATURE being what it is, some engineers are still looking for the universal coating for magnesium; the one finish which will give them perfect adhesion, unlimited resistance to salt spray and cyclic humidity, extreme hardness and abrasion resistance, unlimited flexibility, resistance to high temperatures, and good electrical conductivity so that grounding will be no problem.

The truth is that no one finish can meet the requirements for every service application, since some desirable characteristics are diametrically opposed to others. Similar to protective coatings for other metals, HAE finish for magnesium has excellent properties for many applications but is not suitable for all. However, tests by both government and independent laboratories, and by dozens of manufacturers, indicate that as a protective coating for magnesium surfaces, this new finish does meet the requirements to a greater degree than any other coating or treatments tested.

This electrolytically applied ceramic coating can be used on all magnesium alloys, including the rare earth alloys, and is typically 0.001 in. thick. It is refractory, and has excellent corrosion, abrasion, and heat resistance. The chemicals used in the alkaline solution are potassium hydroxide, aluminum hydroxide, trisodium phosphate, potassium fluoride, and potassium manganate. Parts to be treated need only be given a hot alkaline cleaning and a cold water rinsing, since the process itself contains self-cleaning properties.

Properties

Thickness—The thickness varies with time and amperage used in applying the coating. The first phase involves a chemical union of the material with the surface layer of magnesium, producing a light oatmeal-color surface which is a good base for paint. Indications so far are that this layer of coating without paint is considerably inferior in corrosion resistance to a coating with 0.001 in. or more build-up.

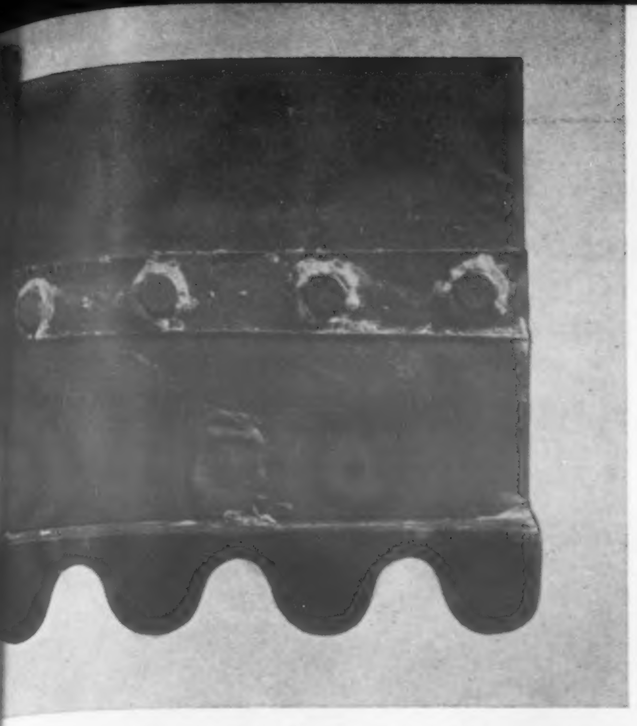
Texture—HAE finish is an excellent base for paint. Painted HAE-treated panels, tested in salt spray for thousands of hours, show no evidence of corrosion.

Hardness and Abrasion Resistance—HAE coating will scratch glass; steel can be sharpened on the surface. Hardness on the Moh scale is between 7 and 8.

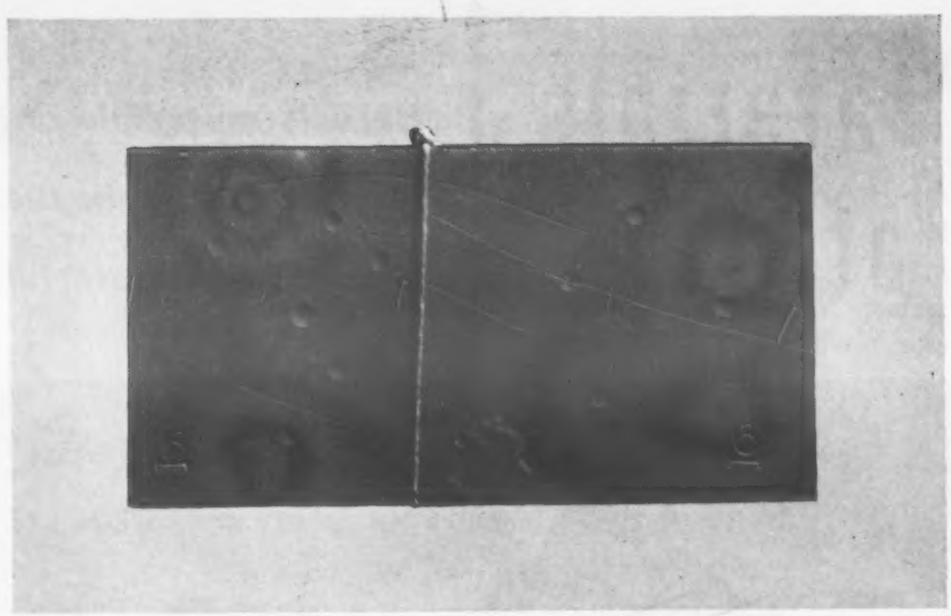
Thermal Shock Resistance and Adhesion—A panel 4 by 6 in. and 0.038 in. thick, treated with HAE, was subjected to a temperature of 1100 F for 30 sec in an electric muffle furnace, withdrawn, then dropped into cold water. The coating did not crack or show any impairment although the magnesium panel buckled slightly. Three other panels of the same dimensions, one having galvanic anodize, one a proprietary anodic treatment, and the third, the dichromate treatment, were given this test. All three panels cracked and broke from thermal shock, indicating that HAE has superior thermal insulating properties and that thermal shock does not affect the adhesion of the coating.

Heat Resistance—HAE provides magnesium with a surface which is resistant to temperatures to above 2500 F. When a treated panel is held vertically and subjected to the flame of two Fisher blast burners, the magnesium will melt locally and form a bulge, but the coating is not impaired. The flexibility of the coating is sufficient to take a considerable bulge without cracking.

Strength and Modulus of Elasticity—Not yet known. A 0.022 in. thick specimen of magnesium loses



Raytheon Mfg. Co. joined these two HAE-treated test panels with 18:8 hardware, then painted with zinc chromate primer and two coats of enamel. After 2000 hr salt spray exposure there is no corrosion. The white deposit is salt crystals.



Raytheon Mfg. Co. painted this HAE-treated magnesium FS-1 panel with zinc chromate primer and two coats of enamel, then hammered it with a ball peen hammer and scratched through to bare metal. After 1500 hr of salt spray it is undamaged by corrosion.

HAE Finish for Magnesium

by R. G. GILLESPIE, Brooks & Perkins, Inc.

about 8% of its tensile strength after a 1½ hr treatment. This loss in tensile strength is approximately proportional to the thickness build-up of the treated specimen, i.e., approximately 80% of the total coating thickness. However, as the thickness of the specimen increases, the percentage loss in tensile strength diminishes. For example, an 0.064 in. thick specimen having a coating 0.0012 in. thick on each side will lose less than 0.5% in tensile strength due to the coating.

Salt Spray Corrosion—The field in which HAE is producing the most revolutionary applications of magnesium are those where salt spray corrosion-resistance has been a limiting factor. The coated magnesium alloy panels show no corrosion up to 24 hr exposure in salt spray, then show only one or two pin-point spots which do not appreciably increase in size or depth up to 200 hr exposure. In regard to tests on waxed samples, Frager and Evangelides wrote in a recent article in *Metal Progress:*

"This surface protection, plus a suitable wax seal, will withstand and has withstood a salt spray exposure of more than 13,000 hr. Similarly, instead of wax, zinc chromate primer or a phenolic finish over the HAE surface will give excellent results. . . . In addition, silicone greases have been used successfully. With all of these methods the effective work of sealing magnesium is done by minute amounts of sealant which close those few pores remaining in the HAE coating at the end of the process."

Galvanic Corrosion—The dielectric strength of the coating at 60 cycles is about 550 v, with a coating thickness of slightly more than one mil. This insulation value indicates a highly non-conductive and impermeable coating. Since the insulating quality is so high, it obviously should be an effective means of preventing galvanic coupling action.

Color—Brown of variable shades. The "oatmeal" coating is very light in color. If the fully treated dark brown HAE coated surface is sealed with a post-treatment dip for 30 sec in a 35 to 50% by volume of 52% hydrofluoric acid, the color becomes lighter and it is more resistant to corrosion.

Limitations

Since HAE coating is a hard refractory ceramic coating, it does not have good elastic properties. Like all ceramic coatings it has limitations where rough handling is encountered, or where a sheet magnesium part will be subjected to flexing. Magnesium panels of 0.025 in. thickness, HAE-coated, can be bent as much as 160 deg and straightened without apparent damage to the coating on the tension side. However, the coating on the compression side is substantially removed by this treatment.

It has been difficult if not impossible to rivet HAE-treated sheet metal parts without cracking and loss of the coating while driving the rivets. Similar difficulties may be experienced with bolted assemblies unless extreme care is exercised. Tests recently performed by Bullock of Raytheon Mfg. Co., have shown the advisability of painting the treated surfaces, preferably with a vinyl paint, before riveting to prevent spalling and damage to the coating. Since these tests have not been conclusive, further investigation is indicated.

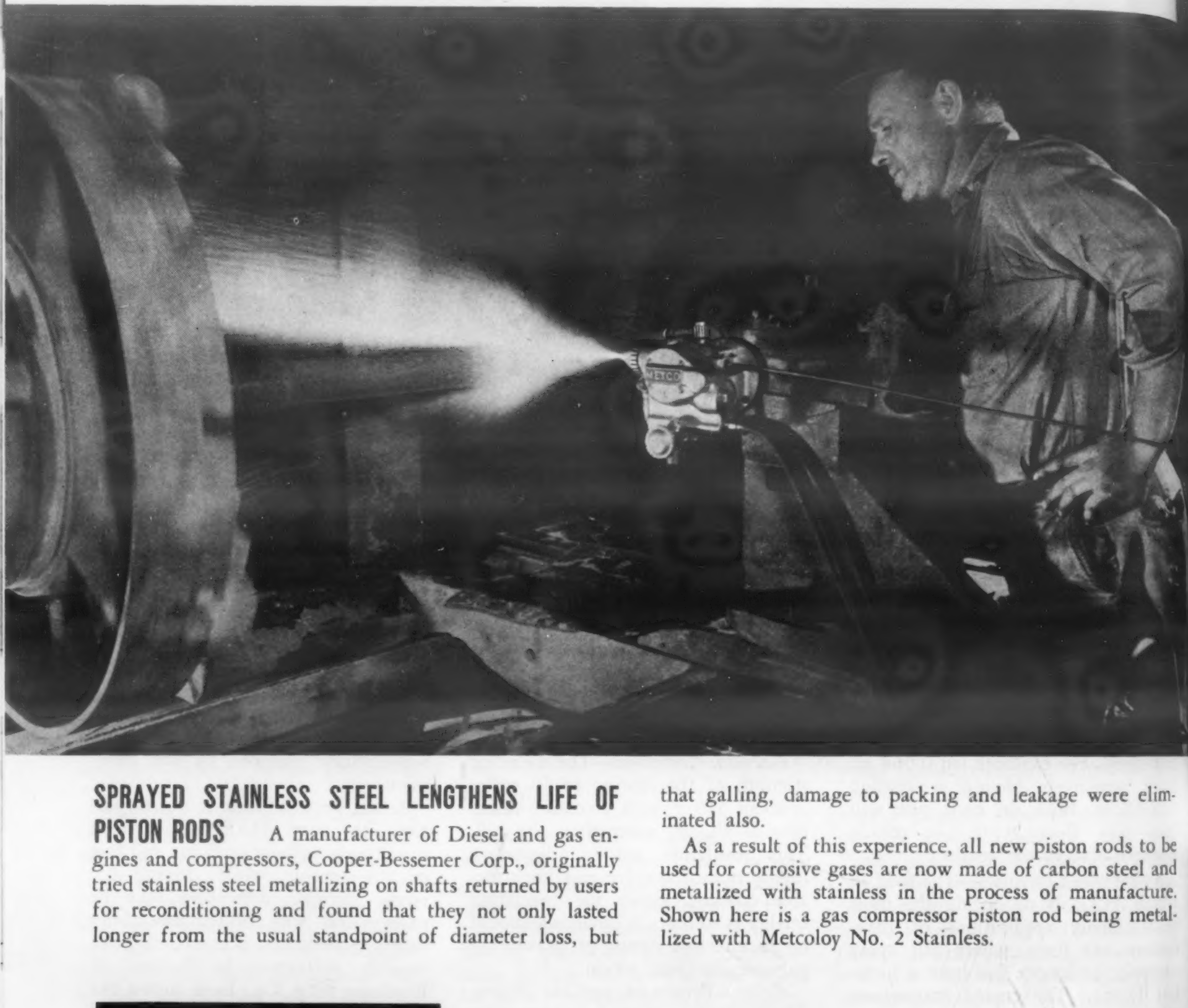
Another handicap in the use of this coating would be that any rework or removal of handling nicks would be extremely difficult because of the hardness of the surface, and the subsequent re-treatment of the surface after rework.

Materials at Work

Here is materials engineering in action . . .

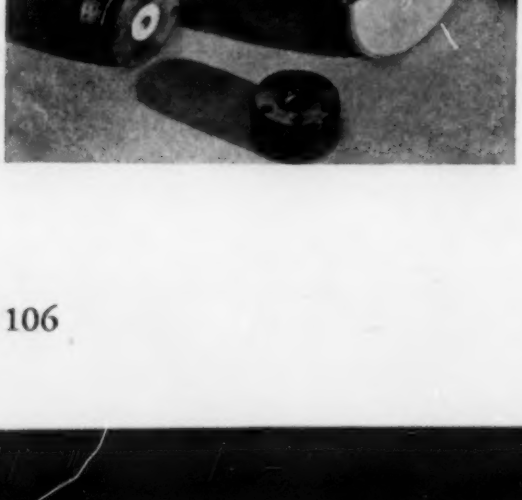
New materials in their intended uses . . .

Older, basic materials in new applications . . .



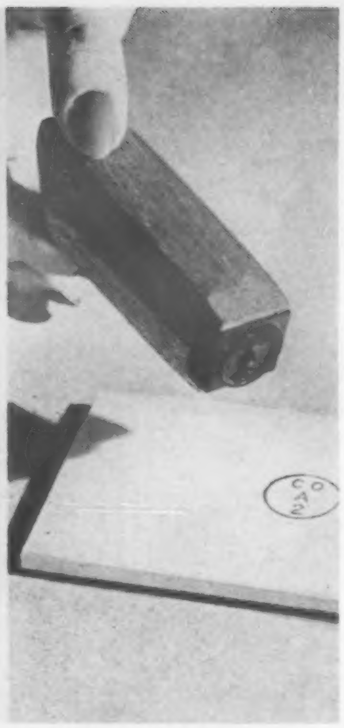
SPRAYED STAINLESS STEEL LENGTHENS LIFE OF PISTON RODS A manufacturer of Diesel and gas engines and compressors, Cooper-Bessemer Corp., originally tried stainless steel metallizing on shafts returned by users for reconditioning and found that they not only lasted longer from the usual standpoint of diameter loss, but that galling, damage to packing and leakage were eliminated also.

As a result of this experience, all new piston rods to be used for corrosive gases are now made of carbon steel and metallized with stainless in the process of manufacture. Shown here is a gas compressor piston rod being metallized with Metcoloy No. 2 Stainless.



PHENOLICS STRENGTHEN PRECISION BOBBINS The use of Durez phenolic plastic plugs in precision bobbins manufactured by Engineered Plastics, Inc., is said to result in less spindle and machine wear and lower power consumption in the production of yarn. The self-tapping screws thread their way into the molded plug and force out the lock ring to hold the entire assembly together.

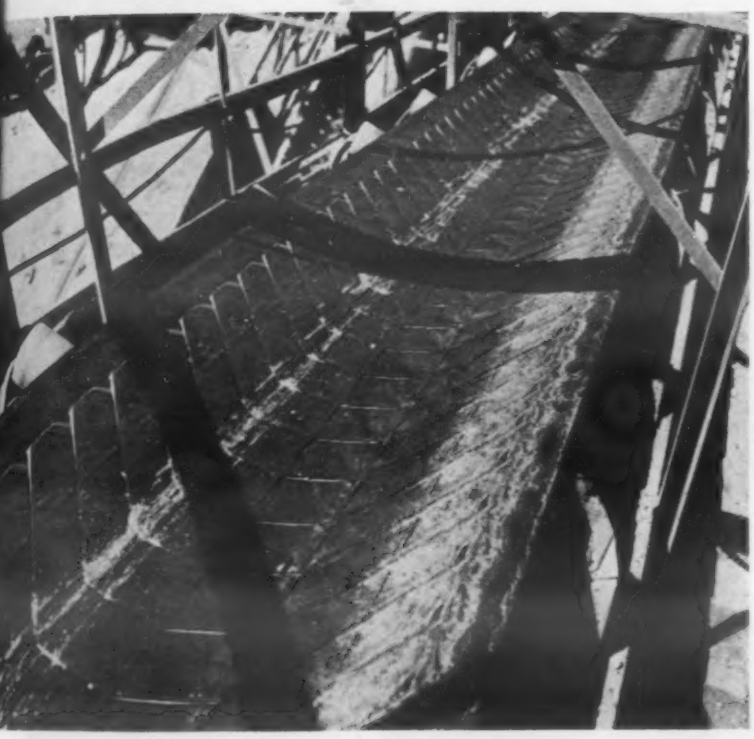
The sheath, the flange and the spindle bearing of the bobbin are laminated plastic, providing a smooth, hard yarn surface, which will generally withstand the pressure of nylon and other yarns even under steaming conditions.



PLASTIC MARKING DEVICES GIVE LONGER LASTING, CLEARER IMPRESSIONS

Sharper, clearer stamp impressions are claimed for new dies molded of Bakelite Co's vinyl resins to three times the depth of ordinary stamps. The acid resistance of the resins extends the life of the stamps when using acid etching inks for permanent stamping on metal and all nonporous surfaces, as specified in government contract work. Vinylite resins resist the action of most chemicals including oils, greases, petroleum solvents, kerosene, benzine and gasoline.

Flexible, resilient dies made of these resins resist abrasive action from repeated stamping and fit smoothly on curved or irregular surfaces. Stamp markings stay sharp longer with deep-molded stamp faces made of Vinylite resins than do those made with ordinary shallow stamps that rapidly clog with heavy base inks and must be cleaned often. The new stamps are adaptable to any type of marking device including pin-and-peg stamp, pocket stamp and self inking midget.



RUBBER CONVEYOR BELT AUTOMATICALLY CONTROLS WATER CONTENT OF LOAD

A unique surface design on a rubber conveyor belt allows the belt to be adjusted to shed or retain water contained in the materials it conveys. Called Riffle Grip, it was developed by the B. F. Goodrich Co.

Operating on a predetermined conveyor incline angle, with belt idlers also placed at a specified angle, the chevron-like ridges channel water to the edges of the belt where it flows off, leaving the conveyed material resting in the center of the belt, free of water. By adjusting the conveyor incline angle and the angle of the belt idlers, the chevron patterned surface can be changed into a series of horizontal carrying ribs which retain water on the belt and permit even distribution of moisture throughout the material.

The belt is now in use in plants where wet sand and gravel must be conveyed up steep inclines, in gold dredging operations for stacking wet rejects and in the dewatering of finely ground taconite.

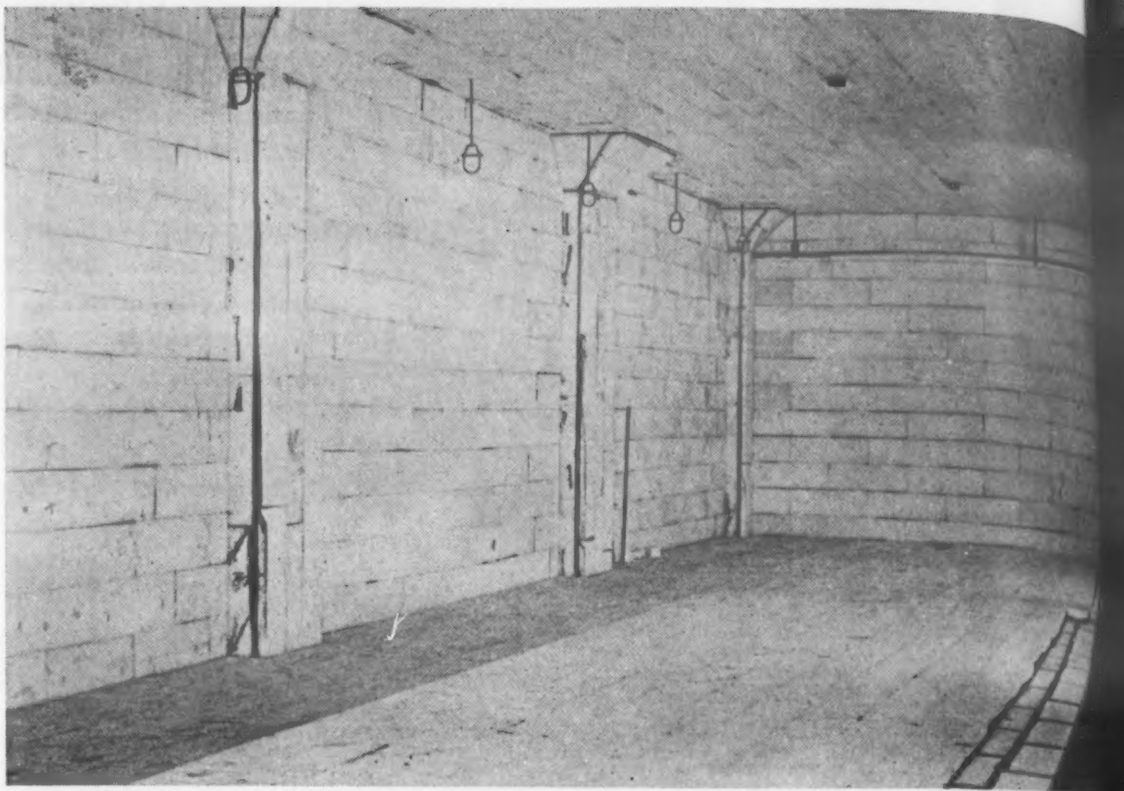
LOW ALLOY TUBING AIDS WEAR RESISTANCE OF HOSE KNITTING MACHINES

After trying various types of materials, the Superior Tube Co., selected Type E-52100 low alloy tubing to meet the exacting requirements for thread carriers in the hose knitting machines of Karl Lieberknecht, Inc. The tubes must handle nylon yarn which is fed at speeds of 1160 to 1233 in. per min. This requires high wear resistance to minimize the grooving action of the thread, yet the tubing must be tough enough so that the breakage rate will be low.

The tubing is supplied in two sizes—0.126 o.d. by 0.087 i.d. for the bell-mouth tube at the top of the carrier where the nylon enters, and 0.050 o.d. by 0.032 i.d. for the bottom of the carrier where the nylon leaves. Both sizes are furnished in the fully annealed condition for easy formability. Tubing for the bell-mouth tube is expanded and chamfered on both ends; the smaller tubing is swaged on the exit end, turned and bored to accurately control the smaller bore size, then chamfered on the other end. After forming, the tubes are heat treated in controlled atmosphere furnaces to a hardness value of 56 to 60 Rockwell C.

FOAMED PLASTIC INSULATES COLD STORAGE ROOM

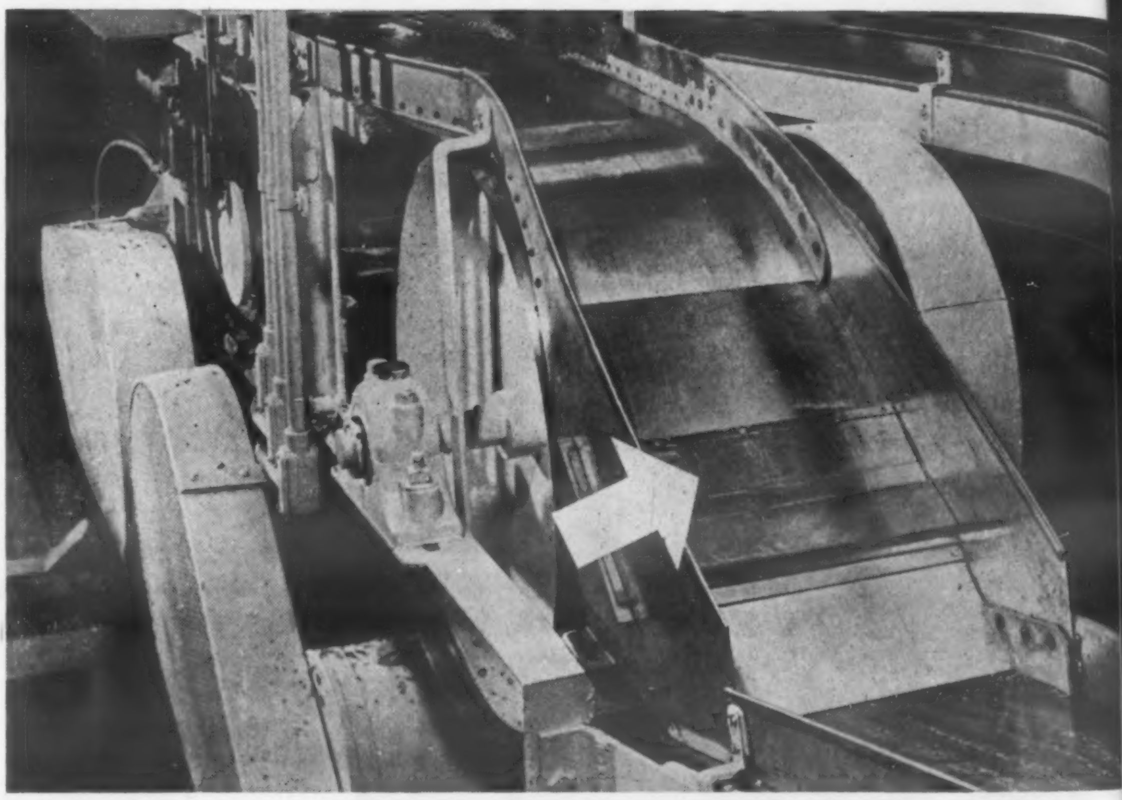
Blocks of Styrofoam, a product of Dow Chemical Co., are used for low temperature insulation in commercial cold storage rooms at Flint Cold Storage Warehouse Co. The foamed polystyrene aids in maintaining temperatures that range from 35 to –10 F, with the thickness of the insulation varying from 4 to 8 in. depending on the temperature to be held.



PERMANENT MAGNET KEEPS TUNA METAL-FREE

As a result of installing eight Eriez permanent magnetic separators in the Terminal Island plant of the Star-Kist Tuna Co., stray tramp metal has been completely eliminated from chunk style tuna fish. As the chunks pass over the 16 in. magnets (arrow) at the discharge ends of stainless steel conveyor belts, any metal contamination is removed. Each magnet handles approximately two to three tons of cleaned tuna meat per hr.

These non-electric stainless steel magnets are liquid tight, sanitary and can easily be cleaned with steam or water and detergent.

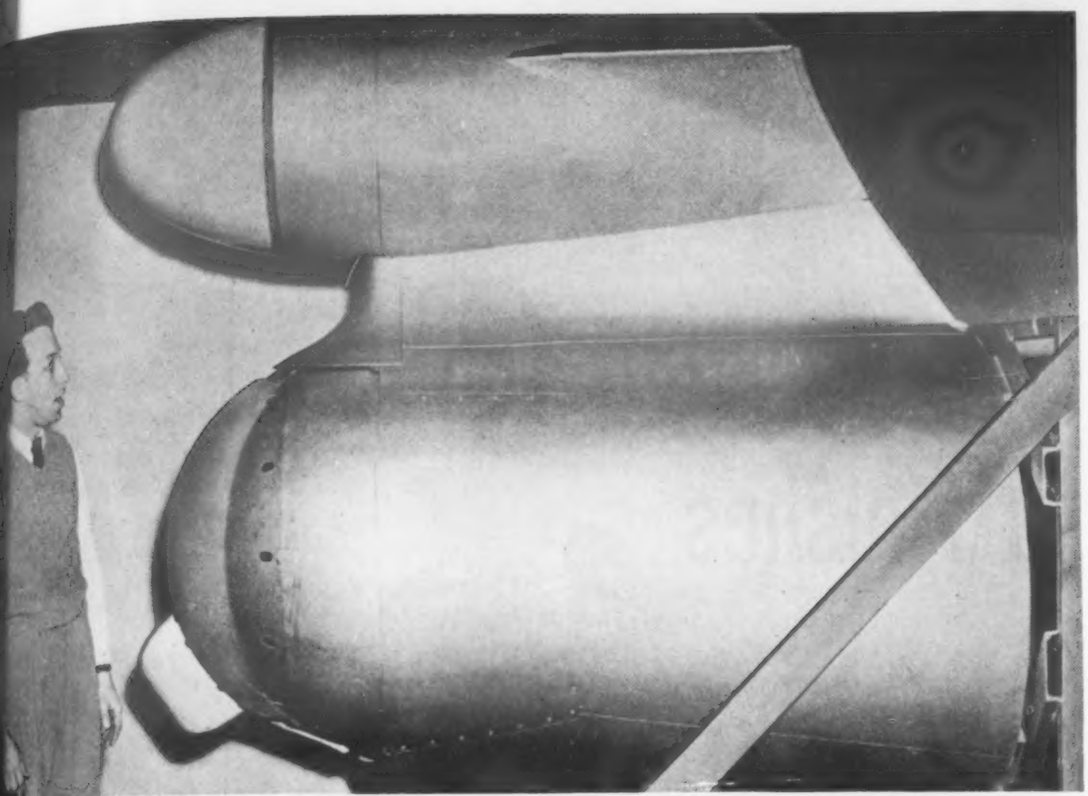


GLASS FIBER AND EPOXY RESIN MAKE HIGH STRENGTH TANKS

A high bond strength epoxy resin known as Epon and produced by Shell Chemical Corp., is being combined with glass fiber to fabricate air storage tanks for new jet aircraft starting system. The tank is 35% lighter than comparable steel tanks, is shatter-proof and has a burst strength of over 7000 psig against operating requirements of 3000 psig.

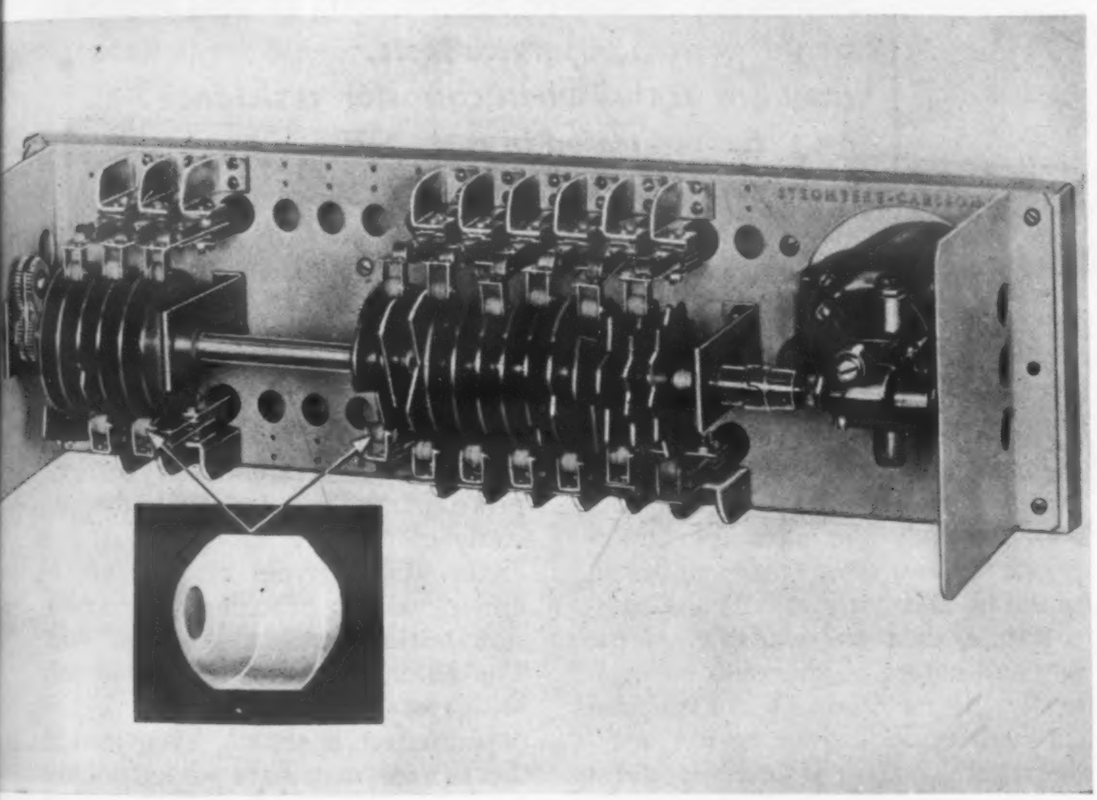
The storage tank is made by running a continuous strand of Fiberglass filament (0.0003 in. dia) through an Epon resin bath and on to a low melting point alloy mold containing the tapped air connection for the tank. The mold is supported by a mandrel screwed into the air connection. After about a two-hour cure, the mold is melted out and recast for further use.

The tank is designed to withstand 10,000 cycles from 0 to 3000 psig and back to 0 at 30 sec intervals without failure. In practice, bond strength between Epon and Fiberglass in these tanks has withstood 26,000 cycles without "weeping" under pressure.



MAGNESIUM KEEPS WEIGHT TO A MINIMUM IN BOMBER TAIL

Magnesium sheet and extruded sections are used in this bomber tail cone and turret enclosure in order to minimize the overall weight of the plane. The skin is formed of sheets 0.051, 0.064 and 0.072 in. thick, and extruded hat sections are used for the framing members. Manufactured by Brooks and Perkins, Inc., for General Electric Co., the gun turret employs two frames of aluminum alloy and two aluminum alloy forgings for support.



NYLON CAM ROLLERS GIVE LONG SERVICE IN CIRCUIT INTERRUPTER

Cam followers made from machined nylon have recently completed more than a billion operations in a circuit interrupter produced by the Stromberg-Carlson Co.

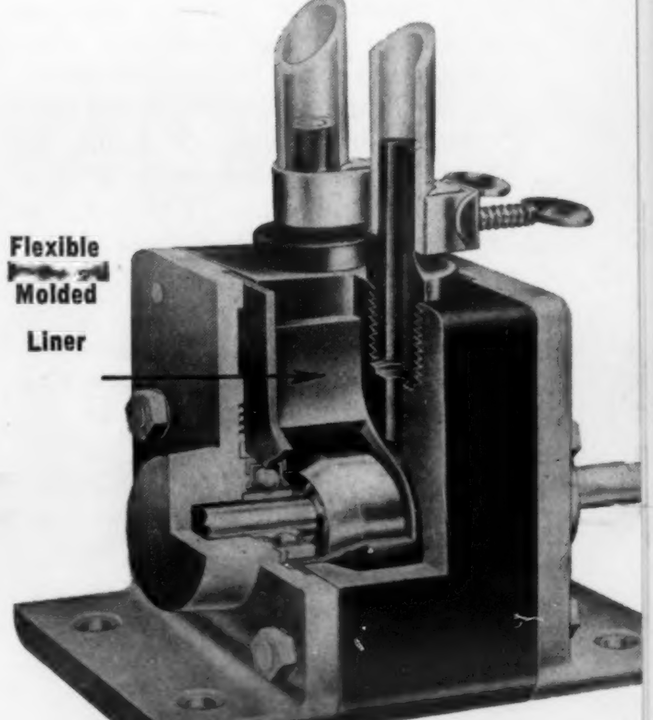
The switches, activated by the nylon cam rollers, have performed these mechanical operations without failure on accelerated life tests equal to 20 yr operation at a rate of 100 impulses per min. A primary cam shaft carrying up to 22 cams, and a secondary cam shaft carrying up to 6 cams operate the snap action switches on the machine. These break-make switches relay the timing and impulse action.

COMPETITIVE MATERIALS COOPERATE IN CORROSION RESISTANT PUMP

Aluminum, carbon steel, stainless steel, natural and synthetic rubbers and a variety of plastic materials are used in the "flex-i-liner" pump designed by the Vanton Pump Corp. to handle corrosive liquids and gases.

The "flex-i-liner" is actuated by a rotor mounted on an eccentric shaft, creating a "squeegee" pressure action against a countersink in the pump body block, resulting in positive displacement of the fluid. Molded flanges on the liner are pressed to both sides of the body block by end plates, thus sealing off the fluid passageway from contact with any moving parts.

The "flex-i-liners" are furnished in pure gum rubber, natural rubber, neoprene, Hycar, Buna N, silicone, vinyl, or Compar, while the pump body blocks are made of Bakelite, Bakelite with graphite filler, hard rubber, polyethylene, or Lucite. With the proper material combinations, the pump can handle a large group of acids, alkalis, industrial alcohols, solvents, distilled water, beverages, food products and other highly corrosive fluids and abrasive slurries.



Three Accelerated Corrosion Tests for Materials and Finishes

by **SAM TOUR,** General Manager, Sam Tour & Co., Inc.

Although simulated service tests cannot replace actual corrosion service tests, they are useful when corrosion resistance must be evaluated in a relatively short time.

● THE BEST PROCEDURE for determining the resistance to corrosion of a particular material or protective coating is in use under actual service conditions. However, unless the materials or the coatings are exceptionally poor for the service intended, the tests must continue for months or years to yield reliable information. To reduce this time interval, accelerated testing which simulates services conditions often becomes necessary.

Although many procedures for accelerated corrosion testing have been developed in laboratories during the past fifty years, none of these have universal application. In fact, no laboratory method has been developed that will give results that can be translated directly into a given service life. In spite of the drawbacks, a great deal of accelerated corrosion testing is and must be carried out in laboratories.

The basic problem in accelerated corrosion testing is to interpret the results obtained in terms of the probable life of the material in service. This problem, recognized by industry at about the turn of the century, has resulted in many field tests to study the effect of atmospheric exposure on many different materials and coatings. At the present time, data are available on the rate and nature of corrosion on practically all materials of construction exposed under atmospheric conditions prevalent in different sections of this country and, to a lesser extent, on different parts of the earth. This somewhat formidable array of data has been used as such and as a basis of comparison for accelerated corrosion studies made in the laboratory.

Alternate Condensation Test

The alternate condensation and evaporation of moisture on the surface of exposed field test specimens has been recognized as a corrosion factor of prime importance in almost all localities. However, very little work has been done in the way of laboratory tests in which this factor was "accelerated".

Salt spray tests, universally used, have been accepted as a standard method of measuring continuity of surface coatings rather than corrosion protection. They are applicable directly only where sea or salt air is a factor. Other types of tests are in use in various procedures for corrosion testing, such as artificial rain. The latter, however, will frequently bridge over pinholes so that no particular effect is shown, even though the surface may have imperfections. Spray washes as used in some weathering machines frequently serve to clean the surface of the test sample, washing away the corrosion products and decreasing the corrosion rate.

An alternate condensation method developed by Sam Tour & Co., Inc., has none of these particular limitations. This method for testing corrosion resistance of a metal or the corrosion protection provided by a coating on a metal appears to offer a technique more comparable to normal weather corrosion than any yet devised. Unlike any of the generally used corrosion resistance testing methods, it uses a condensate rather than a dip or a spray to effect the corrosive action on the metal. Dew

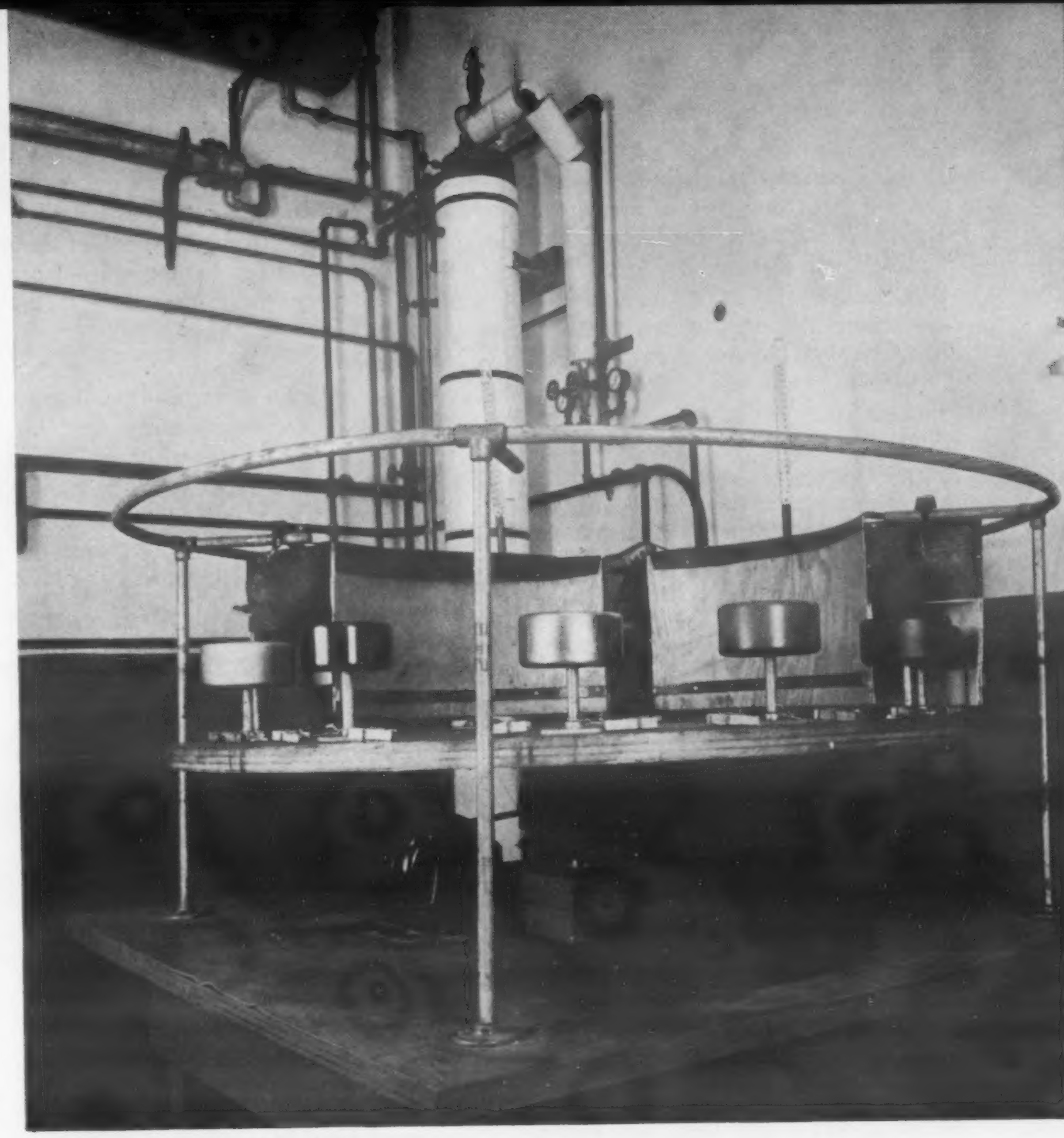
is water condensed from the atmosphere. Water in the form of a thin layer of dew or condensate is water of maximum corrosivity in most intimate contact with the surface of a sample. It actually searches out pinholes, and never bridges them. It accelerates to about a four minute time cycle the weathering action of a full day in any area where the day to night temperature gradient is sufficient to cause dewing.

One of the main features of the testing method is its adaptability to a variety of atmospheric conditions. Specimens can be exposed to varying temperature and varying humidity conditions, as well as to air carrying desired contaminants in controlled quantities. The equipment is inexpensive and quite easily assembled. It consists of a turn-table upon which the samples to be tested are mounted, and two or more chambers through which the turn-table revolves so that the samples are alternately exposed to the atmospheric conditions of each.

In the first chamber, the air which is directed against the samples has an approximate temperature of 70 F and relative humidity of 25%. In the second chamber, there is directed against the samples a stream of air which has been saturated with water vapor at a thermostatically controlled temperature of 160 to 170 F. As the samples are dry and relatively cool on entering this chamber, when they come in contact with this warm, humid air, they rapidly become covered with a film of condensed moisture which remains as they pass through the chamber.

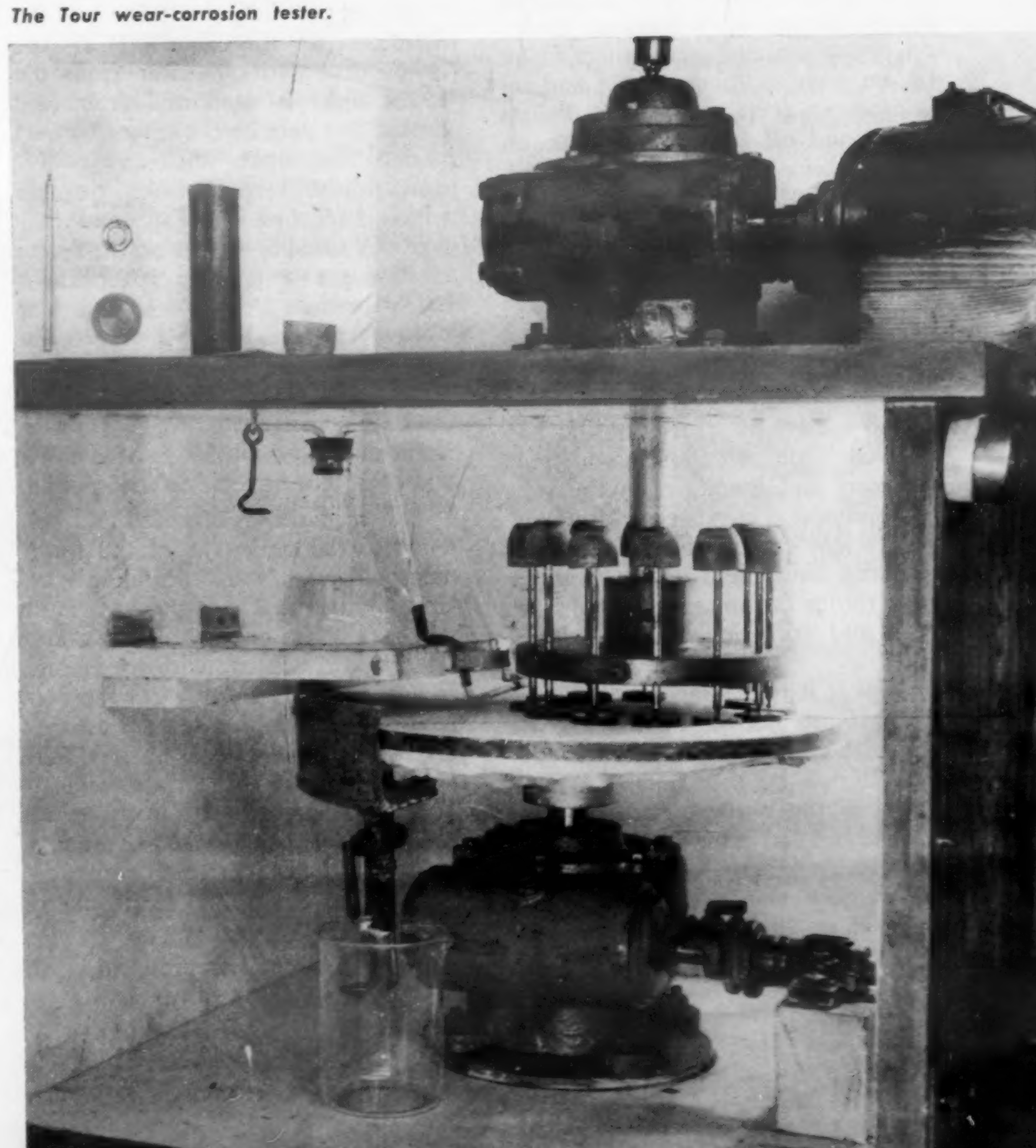
The wet samples emerge from the second chamber into the room atmosphere where they may dry or may pass into a third or fourth chamber. In these third and fourth chambers, there may be admitted controlled quantities of hydrogen sulfide, carbon dioxide, sulfur dioxide as desired. Finally the samples reenter the first chamber to be dried and cooled and repeat the cycle. The complete cycle is carried out 15 times per hr. Results may be evaluated by visual or low-magnification inspection or by change in weight.

The turntable used for mounting the specimens is driven at a predetermined speed by a geared motor. A controlled hot water tower is used to produce the warm saturated air at any desired temperature, and water-cooled condensor is used to cool the dry air for chilling the samples. If warm air drying is de-



An alternate condensation tester.

The Tour wear-corrosion tester.



sirable, an electric heating element can be provided for a drying fan, and chilling can be subsequently handled. If sulfur dioxide or hydrogen sulfide, or other contaminants are desired, they can be introduced in a chamber arranged to follow the condensing chamber. Samples of various sizes and shapes can be handled equally well. As in all corrosion testing, however, specimens must be properly prepared and thoroughly cleaned.

While not a cure-all for difficulties encountered in procedures of corrosion resistance examination, the alternate condensation technique offers a tool that will approximate actual conditions caused by weather exposure. Furthermore, the technique permits acceleration of these conditions sufficiently to make the method adaptable where time is short and concrete evidence is required.

Using this equipment, it has been found that 1020 steel developed noticeable rust within 45 min, 12% chromium stainless steel within 15 hr and well-conditioned 18:8 stainless austenitic steel shows no attack after many days. In a series of tests for various types of coatings applied to steels, it was found that light rusting became evident on black oxide coatings on steel within 6 to 20 hr, on simple phosphate coatings in 26 hr, on phosphate and oil coatings in 50 hr, on poor cadmium plated and oil coatings in 6 hr, on good cadmium plated and oil surface in 26 hr, on poor nickel plated coatings in 26 hr, on good dull nickel plates or copper and nickel plated coatings in 50 hr, whereas good cadmium plated and Iridite treated coatings stood up for some 330 hr.

Wear-Corrosion Testing

The subject of wear-corrosion has received little attention throughout the years and literature on the subject is almost non-existent. However, that freight cars, coal cars, materials handling equipment and a host of other things fail in service from both wear and corrosion is well recognized.

Why is it that wear-corrosion test methods are not in regular use in many laboratories throughout industry? It may be that suitable equipment for the purpose has been developed but that it has not been given adequate publicity. Apparatus for the purpose was developed by the writer some 20 years ago in connection with a study of the relative resistance of various precious metal surface finishes to a combined wear and corrosion exposure. Since that time the apparatus has been used on a number of non-precious metal wear-corrosion problems.

The Tour wear-corrosion tester consists of two horizontal disks of different diameters and mounted on separate shafts to allow the independent rotation of each. The lower disk of metal is covered with cloth or canvas stretched over its surface and held in place by a tension band. A sectional drip trough catches the surplus liquid that drains or is thrown off of the disk. On a shelf above and to the left of center of the lower disk is a glass vessel to contain the supply of corrosive solution. This vessel is supplied with a siphon tube leading to a rubber tube and an orifice from which the solution drops onto the lower disk. On the edge of the shelf is a spring clamp which keeps the rubber tube closed except at the moment it is opened by the action of a clamp-opening button or screw on the periphery of the upper disk. For each revolution of the upper disk, the spring clamp is opened for a moment and several drops of liquid are allowed to siphon onto the lower disk.

The upper disk, about one-half the diameter of the diameter of the lower disk and off-center from the lower disk, is supported from and caused to rotate by the upper vertical shaft. This upper disk has twelve smooth-bore vertical holes through which hardened steel spindles may float. A suitable weight on the upper end of the spindle is spherical or ball-shaped to ride in a ball seat or socket machined in a specimen-holder. The specimen-holder is a flat disk about $1\frac{1}{2}$ in. in dia, $\frac{1}{4}$ in. thick which is thus free to rotate about its center while it is held down and caused to traverse by the spindle.

The specimen is centered and fastened to the underside of the specimen-holder by means of sealing wax. It is obvious that the specimen must not have sharp edges or corners and should be concentric with the holder and spindle. A slightly convex surface is desirable; an annular convex surface is superior; a special half round washer about 1 in. dia is ideal. This shape of specimen made of brass and of steel has been used to evaluate the wear-corrosion resistance of various forms of electroplated coatings.

The wear-corrosion resistance of plated specimens can be evaluated by determining the time to wear through to base metal. Various spot tests reagents are used under a binocular microscope to determine when various successive layers of electroplated metals are worn through. For a given set of conditions as to load, corrosive media and abrasive, the relative time to wear through is a measure of the wear-corrosion resistance. The wear-corrosion resistance of solid materials can be evaluated by change of weight measurements after a constant time of exposure under a given set of conditions.

In actual test work with this apparatus, it has been found that a pitting type of corrosion may occur as well as the expected wear-corrosion. When pitting takes place, it usually is on the portion of surface not subject to wear, but kept wet with the highly aerated corrosive liquid media. The duration of a test will depend upon the wear-corrosion resistance of the specimen and the conditions selected for the test.

A few examples of results obtained with this test are as follows:

Palladium, palladium plus rhodium, rhodium and platinum electroplated on nickel silver disks. In this case, flaking, pitting and wear evaluations were obtained in three hours.

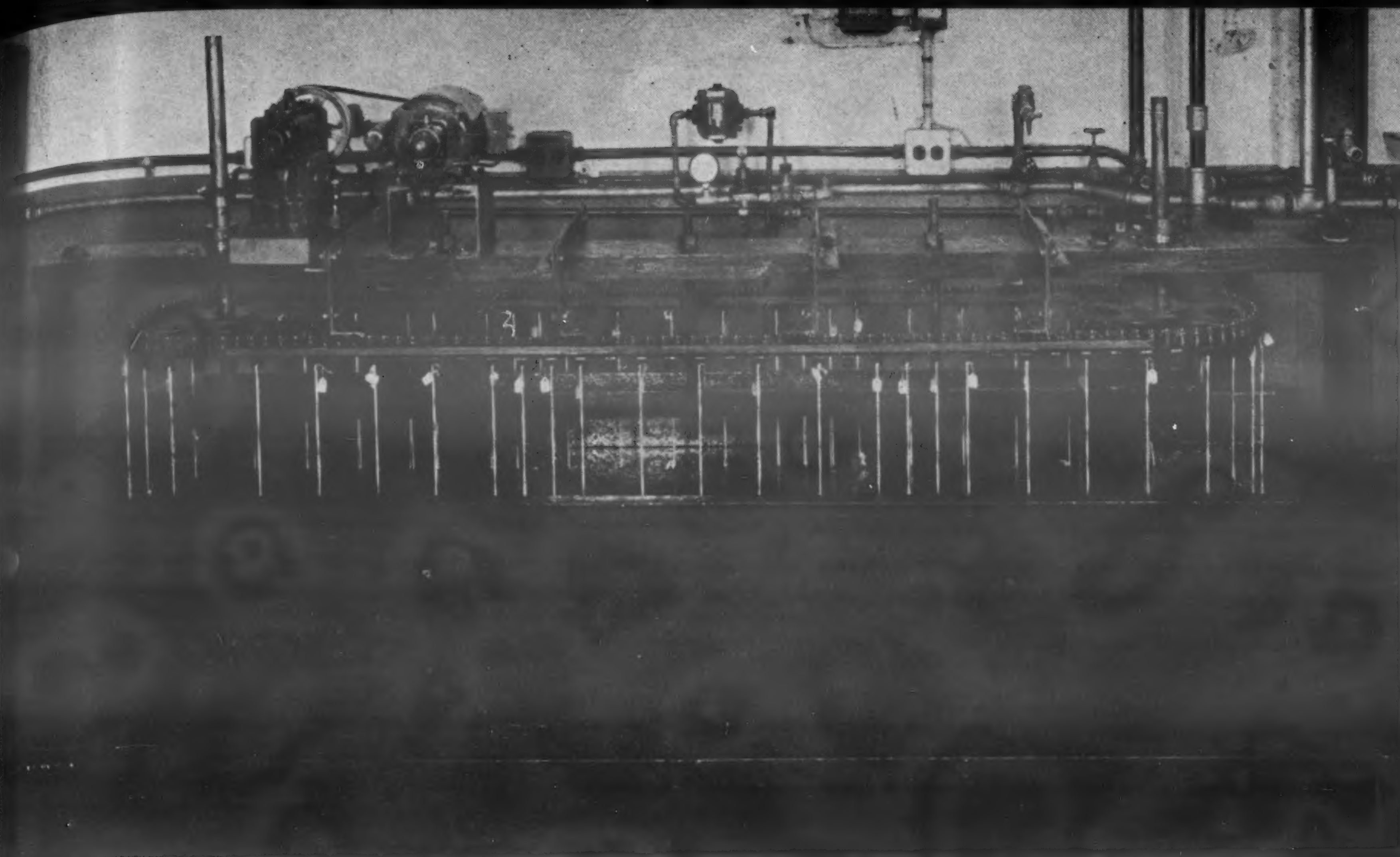
Rhodium plate on nickel plate on a brass platter. The rhodium on the top polished surface wore through in 80 min and the underplate of nickel wore through to the brass in an additional 18 min. The rhodium on the bottom satin finished surface wore through in 25 min and the underplate of nickel wore through to the brass in an additional 19 min.

Heavy platinum electroplate on nickel silver base metal with and without a heat treatment subsequent to plating. Wear corrosion failure and severe pitting in 25 hr of the non-heat treated samples. Very few pits and no failure of the heat treated samples after $27\frac{1}{2}$ hr.

Electroplated gold on electroplated nickel on brass pen clips. The gold layer wore through in 36 to 45 sec and the underlying nickel layer in an additional 15 to 30 sec.

Nickel electroplate on nickel silver, stainless steel and white rolled gold plate on nickel silver in the form of watch backs. The gold wore through in $7\frac{1}{4}$ hr; the stainless steel began to show rust stain in $9\frac{1}{2}$ hr, and the heavy electroplated nickel stood up for $49\frac{1}{4}$ hr.

Four types of black coatings on



Aerated sea water testing unit.

steel. One type failed in 22 min, while the better type lasted 33 min before failure.

Chromium on brass, chromium over nickel on brass, rhodium over nickel on brass, and the same materials on steels. The heavy chromium plates were still intact after 34 hr. The light chromium plate wore through to the nickel in 15 to 40 min. The rhodium plates wore through to the nickel in 10 to 20 min. The nickel underplates wore through to the base metal in $1\frac{1}{2}$ to $2\frac{1}{4}$ hr on steel and in 3 to $3\frac{1}{2}$ hr on brass.

Aerated Sea Water Testing

Aerated sea water testing is a form of laboratory total immersion testing. This type of testing was the subject of extensive work by ASTM Committee B-3 on Corrosion of Nonferrous Metals and Alloys. Recommended procedures are given in ASTM-B-185-43T. Those recommended procedures do not limit the apparatus that may be used but outline the degree of control that should be exercised on temperature, aeration, volume of solution, etc. The recommended minimum requirements for film formation in aerated sea water as given in these ASTM specifications are 4 l of sea water per sq decimeter of specimen surface and 200 cu cm of air per min per l of solution.

Often, corrosion testing is for the purpose of obtaining relative values between different material. Due to the many variables affecting corrosion behavior of any one specimen, it is usual to make simultaneous tests of a number of specimens of each material. In other words, corrosion testing often involves rather large numbers of specimens. Apparatus for corrosion testing should be such as to accommodate numerous specimens at one time.

The equipment shown in the accompanying photograph is such an apparatus for testing in aerated sea water. It consists of a tank about 8 ft long by 3 ft wide by $1\frac{1}{2}$ ft deep above which is mounted a sprocket chain drive. The sprocket chain is equipped with link attachments to allow suspension of the specimens by means of a glass rope. Aeration of the solution is accomplished by leading compressed air at about 15 psi pressure into three RA98 Alundum thimbles placed centrally along the bottom of the tank. The rate of air flow is regulated by a reducing valve and air flow meter arrangement shown at the top center of the photograph. The inside of the tank, the air piping and all metal parts in the vicinity of the solution are kept coated with asphalt paint. The chain travels at a rate of about $6\frac{1}{2}$ ft per min. The entire unit is operated at room temperature. During a test, the level of solution is maintained relatively constant by daily additions of distilled water to replace the water lost by evaporation. The test solution is drained out and replenished by fresh solution at stated intervals dependent upon the nature of the test. The progress of corrosion can be recorded in terms of appearances or by periodic removing, washing, drying and weighing of the specimens to determine weight changes. This equipment has been used with natural sea water, with sea water made up with $3\frac{1}{2}\%$ by weight of sea salt in water and with plain tap water.

Tests conducted simultaneously on 24 sections cut from bronze propellers of various makes, vintages and compositions gave definite conclusions. On some there was evidence of attack within 24 hr and noticeable corrosion in 48 to 92 hr. On the best the noticeable corrosion did not become evident until after 720 hr of exposure.

Tests conducted simultaneously in natural sea water on steel panels with various types of protective coatings such as paints, sprayed plastics and impregnated metallized coatings, have shown rateable results within 30 to 60 days. Tests conducted on wood panels with and without various forms or protective coatings have yielded valuable results in up to 90 days.

Specifying Elastomers for Lo

An M & M Staff Report on:

Increasing application of products and parts to extreme cold requires that materials' low temperature properties be carefully evaluated.

1

What Happens to Rubbers at Low Temperatures

2

How Common Elastomers Differ in Their Low Temperature Behavior

3

How They Can be Altered to Meet Specific Low Temperature Conditions

● AIRCRAFT AND MILITARY equipment designed to operate at extremely low temperatures (below —60 F in many cases) have forced the development of natural and synthetic rubber compounds that can operate successfully in extreme cold. Good low temperature properties are achieved by special compounding. To get these properties, however, some compromises must be made on other desirable characteristics. It is believed that a knowledge of the low temperature behavior of elastomers and how it can be controlled may be of great value in correctly specifying rubbers and rubber parts and, thereby, minimizing low temperature failures.

Effects of Low Temperature

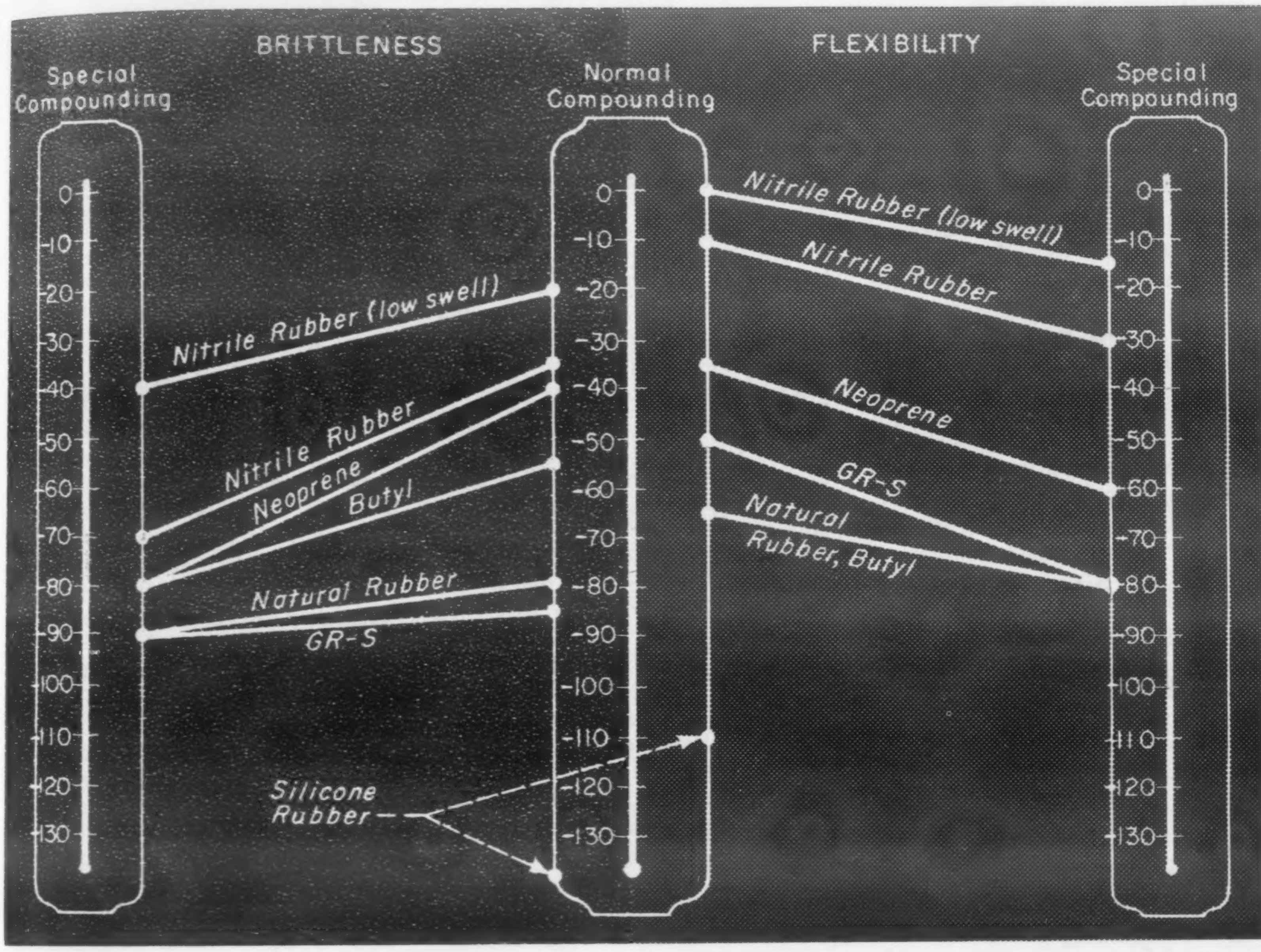
A number of changes can take place in an elastomer as a result of exposure to low temperature. All of these changes are reversible, however. Returning the composition to room temperature or slightly elevated temperatures results in a restoration of its original properties. This is in contrast to the effects of high temperature exposure which permanently change the composition.

Rapid Changes—Imagine a specimen exposed to successively lower temperatures, being held at each temperature only long enough for thermal equilibrium to be established. Fig 1 shows graphically the effect of such cooling on stiffness. As the temperature is decreased (Zone A), the specimen becomes progressively more difficult to bend or stretch. This increase in stiffness is more or less gradual until a particular subzero temperature range is reached. In this range (Zone B), which is specific for a given composition, stiffness increases sharply with a decrease in temperature, so that within a range of about 20 F stiffness may increase a hundredfold or more. Further cooling produces little additional increase in stiffness (Zone C). The changes which cause the gradual increase in stiffness in Zone A are known as simple "temperature effects." Those which cause sharp stiffening in Zone B are known as "second order transition effects."

At some temperature in Zone B or C the specimen becomes brittle and will shatter on sudden bending or on impact. The temperature at which this occurs depends on the rate of application of load. When determined under specific testing conditions, it is known as the "brittle temperature" or, more commonly, the "brittle point". The brittle point bears no definite relationship to the stiffness curve. This is to be expected inasmuch as stiffness tests usually involve low-speed, low-deflection loading, while brittleness tests involve impact (i.e., high-speed, high-deflection) loading. The lack of relationship is often pronounced.

Crystallization — Long-time exposure produces two other kinds of changes. One such change is known as "crystallization," or "first order transition." As indicated in Fig 2, crystallization results in stiffening

for Low Temperature Service



This chart shows minimum temperatures at which various elastomers are useful, using brittle point (left) and flexibility (right) as evaluating criteria.

which is only evident after prolonged exposure. It may require hours, days or even weeks, depending upon the exposure temperature and on the particular composition involved. While crystallization results in an increase in stiffness, it does not necessarily result in brittleness. Nor does the fact that crystallization has taken place appear to affect the brittle point of the composition.

Among the major elastomers, natural rubber, butyl rubber and most types of neoprene are crystallizable. With all of these, the rate of crystallization is increased by placing the vulcanizate under strain. For each elastomer there is a temperature at which crystallization takes place most rapidly. In fact, at extremely low temperatures (e.g., −50 F) or at elevated temperatures neither neoprene nor natural rubber crystallizes. Since crystallization is a time effect and does not take place at extremely low temperatures, it is not evident if the elastomers are cooled more or less rapidly through the range in which crystallization ordinarily can occur.

Plasticizer-Time Effects — While crystallization is the most important time effect associated with low temperatures, there is a second effect which merits some discussion. It is known as the plasticizer-time effect. Practically all compounds designed for low temperature service contain substantial quantities of special plasticizers which are used to improve low temperature flexibility and to depress the brittle point of the composition. Under ordinary temperature conditions such plasticizers are highly compatible with elastomers, i.e., they are soluble in the elastomer. Upon prolonged exposure to low temperatures, however, the compatibility of the plasticizer is reduced and a portion of it is thrown out of solution. This portion, of course, is of no value in reducing the brittle point or in promoting flexibility; consequently, plasticizer-time effects may result in two changes in the composition. First, its flexibility at temperatures above the brittle point may be reduced; second, its brittle point may be raised several degrees. Generally speaking, plasticizer-time effects are

apparent only after prolonged exposure at extremely low temperatures, such as −40 F, and are noted only when large quantities of certain plasticizers are used.

To illustrate the damage that plasticizer-time effects can cause, consider a hypothetical case involving hydraulic hose on an airplane. Assume that the hose has been compounded to have a brittle point in the neighborhood of −65 F. If the aircraft is based in the arctic, it is conceivable that the plane would be exposed to a temperature of −40 F for several days. Under these conditions, some of the plasticizer in the compound might come out of solution as a result of plasticizer-time effects. Consequently, less plasticizer would be available for its intended purpose, and the brittle point of the composition would be increased, perhaps as much as 10 or 15 F. At high altitudes, it is quite possible that the temperature to which it was exposed during flight would be lower than the new brittle point and failure of the hose might result.

Comparison of Rubbers

A rough idea of how the commercially available elastomers stack up with respect to flexibility and brittleness at low temperatures can be obtained from the accompanying chart. The chart shows the inherent properties of each elastomer (shown under the heading "Normal Compounding") as well as a figure which indicates the best that can be done with each by the use of special compounding techniques (indicated as "Special Compounding").

At best brittle temperatures are merely comparative. They are obtained by a laboratory test which involves a controlled rate of application of stress on a specimen of standard shape. Since rate of loading and the geometry of the part have a lot to do with the temperature at which it displays brittleness, the figures in the table do not have a specific meaning for the designer.

For most parts in which the possibility of impact during service is present, it is probably safe to say that they will shatter at somewhat higher temperatures than those indicated in the table. The "Flexibility" column shows the temperature at which Young's modulus in flexure reaches 10,000 psi. These figures are a pretty good rough guide to flexibility, but they must be taken with a grain of salt. Because of the peculiarities of elastomers, a figure for Young's modulus can only be obtained at low strains. This is quite different from the conditions which exist in many practical applications.

Silicone rubbers head the list when it comes to either low brittle point or flexibility. They are also well up the list when it comes to other important properties like ozone resistance, heat resistance and dielectric properties. But they have two serious disadvantages — they are expensive and they do not have the physical strength to handle many applications for which other types of rubber are satisfactory. However, as manufacturers of silicone rubbers point out, their products are not designed to compete with organic rubbers in the normal temperature range (i.e., −65 F to +300 F).

Natural rubber come next, as judged on the basis of both low temperature flexibility and brittle temperature. The strength, abrasion resistance and dynamic properties of natural rubber are also excellent, but natural rubber is unsatisfactory if oil resistance or ozone resistance is necessary.

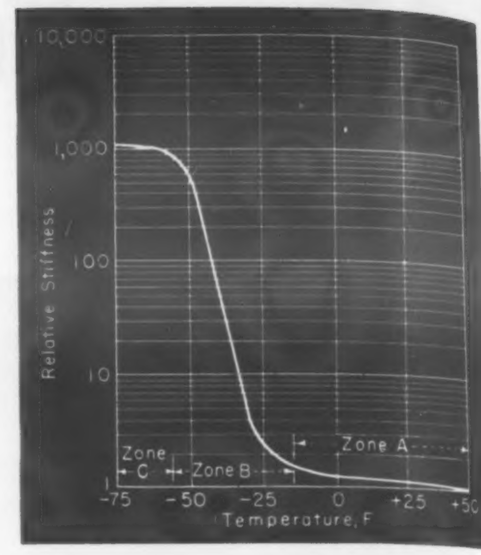


Fig 1—Stiffness vs. temperature—a typical curve for short time exposures.

Third place goes either to butyl or GR-S, depending on whether flexibility or brittleness is the limiting factor. For low temperature flexibility, butyl is better. Butyl also has excellent resistance to oxygen, ozone and chemicals. Its resilience is poor, though, and like natural rubber, it is not oil resistant. GR-S has an inherently low brittle point and is fair with respect to low temperature flexibility. Its other properties make it pretty useful, but it shares rubber's deficiencies —poor oil and ozone resistance— without natural rubber's outstanding advantage in dynamic characteristics.

Neoprene comes next in the scale with an inherent brittle point of −40 F. The dynamic properties and toughness of neoprene compare favorably with those of natural rubber, and neoprene has the added advantage of oil resistance and excellent resistance to aging, ozone, and weathering. There are two figures for nitrile rubber, since this family of polymers can be made with different ratios of butadiene and acrylonitrile. The higher the acrylonitrile

Fig 2—Resilience vs. temperature for several elastomers.

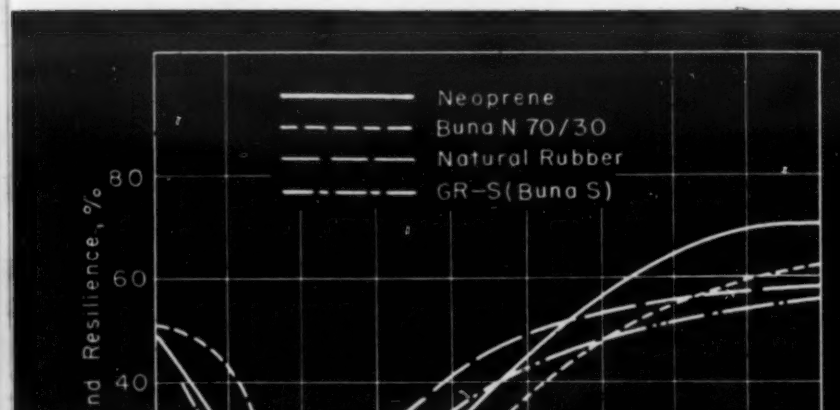
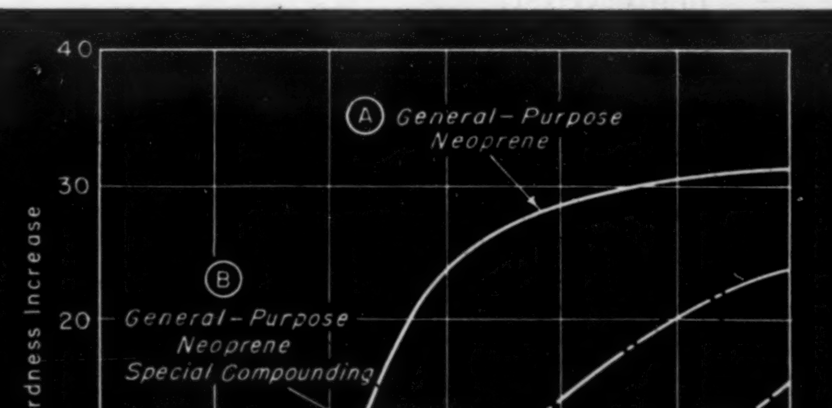


Fig 3—Crystallization of neoprene at 32 F



content the better the oil resistance, but the poorer the low temperature properties. The two figures in the table bracket the range covered by the most commonly used nitrile polymers. Although these polymers rank high in oil resistance, they are not too good for applications requiring good ozone resistance or good dynamic properties.

It is evident that natural rubber and the common synthetic rubbers offer a fairly broad range of inherent low temperature properties. Of course, key requirements such as oil resistance often make it necessary to select types which do not offer the optimum low temperature characteristics. In such cases, it is usually possible to improve these properties by special compounding.

Improving Properties

Generally, improvements in low temperature flexibility are obtained by the use of certain types of plasticizers in the compound. Not all types of rubber can take equal advantage of the improvements obtainable by the use of low temperature plasticizers. As a rule of thumb, the greatest improvement in brittle point can be obtained with the oil-resistant materials such as neoprene and nitrile rubber; relatively less improvement can be made with the non-oil-resistant rubbers like GR-S, butyl and natural rubber. The silicone rubbers are a special case because the rubber goods manufacturer has relatively little latitude in compounding them. In fact, with many silicone rubbers he is pretty much confined to fabricating the finished product from an existing compound which he buys.

The chart gives an idea of the best that can be done in a practical way with the various rubbers, taking full advantage of compounding techniques. The improvement in brittle temperature obtained by special compounding is especially noticeable with neoprene and the nitrile types. With natural rubber, butyl and GR-S, somewhat less decrease in brittle temperature can be obtained.

Dynamic Applications

For many uses it is important to know what the resilience of a compound will be at low temperature. Unfortunately, resilience is unusually susceptible to change with temperature. For example, a rubber compound ceases to exhibit its characteristic bounce and snap at temperatures 30 or 40 degrees above the brittle temperature. The effect of temperature on the resilience of compounds of several elastomers is shown in Fig 2. The shapes of all the curves are quite similar. A drop in temperature results in a decrease in resilience down to a minimum. At lower temperatures, resilience increases quite rapidly. But "resilience" at temperatures below the minimum in the curve is quite different from the "rubbery" resilience of ordinary temperatures. For, below the minimum point, the compounds behave more like unyielding solids when subjected to high speed stress. Their resilience is more akin to that of steel, for example, than to that usually characteristic of rubber.

The special compounding techniques used to improve low temperature flexibility also shift the minimum point in the resilience-temperature curve toward lower temperatures. The magnitude of this effect in a neoprene compound is illustrated by the following data which show the temperature of minimum resilience for compositions containing various amounts of a low temperature plasticizer:

Parts Plasticizer	Temp. F for Min. Resilience
0	−4
20	−20
40	−33

Loss of resilience and elasticity is especially important in vibration isolators. It might be expected that vibration of a rubber mounting would soon restore it to something approaching "normal" operation since internal friction would cause it to warm up. But this may not always happen. Some researchers report that for any given set of conditions (i.e., compound, mounting, frequency and amplitude) there is a temperature below which a composition will not warm up no matter how long it is vibrated. This temperature is referred to as the "barrier point". The data below show the barrier points of 40 durometer hardness mounting compounds of various elastomers at 1800 cycles per min and amplitudes of less than 0.015 in.

	"Barrier Points" of Compounds of Various Elastomers, F
Natural rubber	−42
GR-S	−25
Neoprene	−18
Butyl	+2
Nitrile rubber (low swell)	+15

There is an important point in these data; static tests are not a reliable guide to dynamic performance at low temperatures. For example, the superior low temperature properties of GR-S and butyl, as judged by brittle temperature, are not apparent under dynamic conditions. In fact the data show butyl to be less desirable than neoprene for vibration isolation at low temperatures, even though the inherent brittle temperature of butyl compounds is about 15 F lower than that of neoprene.

Other Service Conditions

So far the extent to which these low temperature properties will change in service has not been considered. The one thing that will have the greatest effect is loss of plasticizer. This usually occurs either as a result of exposure to high temperatures which boil off the plasticizer, or as a result of service in contact with fuels or solvents that leach out plasticizer. If contact with solvents is continuous, however, low temperature properties may actually improve because the solvent absorbed by the elastomer acts as an excellent low temperature plasticizer. The data in

Table 1—Effect of Solvent Extraction on Stiffness of Elastomers

Conditions	Temperature (F) at which stiffness increases rapidly with small drop in temperature		
	Neoprene	Buna N	Buna N (low swell)
Original	−45	−45	−45
After extraction in 80 octane gasoline	−30	+30	+30
After extraction in 40% aromatics gasoline	−30	−15	−2

WHEN BUYING RUBBER PARTS FOR LOW TEMPERATURES . . .
. . . Be Sure to Give Your Supplier the Answers to These Questions:

1. What is the lowest temperature to which the part will be exposed during shipment or storage?
2. What is the lowest temperature at which the part must perform its normal function?
3. What is the longest period for which it will be exposed to low temperatures?
4. Will it be exposed for prolonged periods in the range −30 F to +40 F? If so, will it be under strain?
5. Will the part be subjected to strain at low temperatures? If so, how rapidly and to what extent?
6. Will it be expected to isolate vibration at low temperatures? If so, what frequency and amplitude?
7. Will the part be subjected to elevated temperatures, too? How high and for how long?
8. Will the part function in contact with gasoline or other fuels and solvents? If so, what are they? Will contact be continuous or intermittent? After "drying out" of the solvent, will the part be subjected to low temperatures again?

Table 1 shows the effect of solvent extraction on stiffness for low temperature compounds of neoprene and two types of nitrile rubber. Specimens were extracted for 7 days at 170 F, then dried for 15 min at 180 F before testing. The data in Table 2 show how continuous contact with fuels can actually improve low temperature properties by virtue of the plasticizing effect of the fuel. No special attempt was made to compound the test specimens for good low temperature properties. It is evident that for a given elastomer, the greater the swelling power of a fuel or solvent, the greater the improvement in low temperature properties. In addition, the more oil-resistant the elastomer the less evident is the improvement due to contact with solvents.

As for the principal time effect—crystallization—GR-S and nitrile rubbers can be ignored because these rubbers are essentially non-crystallizable. With natural rubber, butyl and most types of neoprene, though, there are several things to consider. Each of these elastomers has a temperature at which crystallization takes place most rapidly. For natural rubber, it is about + 5 F; for butyl, it is somewhere in the range of −40 to −60 F; and for neoprene somewhere around +32 F. At room temperature or at extremely low temperatures (e.g., −50 F), crystallization takes place so slowly that it usually can be ignored. In all cases, crystallization takes place more rapidly when the vulcanizate is under strain.

Tests on tire tread type compounds of natural rubber, butyl and neoprene exposed under no strain at −22 F have shown that they all increase in stiffness by tenfold after 50 days. After 10 days at this temperature, the natural rubber and butyl specimens showed no measurable stiffening while the neoprene sample had stiffened about threefold.

Crystallization in neoprene can be minimized so that it does not interfere with the proper functioning of finished products. Fig 3 compares the crystallization characteristics of three different neoprene compounds as judged by hardness increase. Special compounding techniques produce a definite improvement in the crystallization resistance of the general-purpose neoprene polymers. Even better results can be obtained by using one of the types of neoprene that is modified during polymerization so as to have improved crystallization resistance.

Plasticizer-time effects are generally noted only when large quantities of certain types of plasticizers are used. Fortunately there are plasticizers available which do not come out of solution after prolonged temperature exposure, even when they are used in large quantities. But the rubber goods manufacturer should be informed if the product may be exposed at extremely low temperatures for long periods of time. That will be the signal for him to choose the plasticizer carefully.

But improvement of low temperature flexibility with plasticizers usually means a loss in some of the properties which also may be important to the application. For example, large quantities of plasticizer generally impair the resistance to tearing and abrasion. They often impair heat resistance too, because at high temperature the plasticizer will "boil off". And solvents may leach the plasticizer from the compound and alter the low temperature properties of the product, to say nothing of contaminating the solvent itself. Obviously it is not always possible to select the compound with the best low temperature properties.

All these factors show why it is necessary to spell out the intended service as completely as possible so that the rubber products supplier can do the best job of designing his compound. As long as a compromise is necessary, help him make the best compromise by giving him all the facts he may need. As a rough guide, include the answers to the questions in the accompanying table.

Table 2—Plasticizing Effect of Continuous Contact With Fuels

Conditions	Brittle Temperature, F		
	Neoprene	Nitrile Rubber	Nitrile Rubber (low swell)
Original	−32	−17	+8
After 30 days' immersion at room temperature in:			
Isooctane	−60	−32	+6
Gasoline	−87	−42	−5
Gasoline with aromatics	<−107	<−107	−63

YOU MUST CONSIDER . . .

- Contamination Present
- The Metal
- Part Design
- Subsequent Operations
- Equipment Needed
- Operating Conditions
- Special Precautions
- Production Volume
- Cost

in Selecting Metal Cleaning Methods

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

MATERIALS & METHODS
Manual No. 99

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

Prerequisite for most metal finishes is a clean metal surface. Here is a unique comparison of standard metal cleaning methods that will help you select the optimum method for your own particular application.

It is generally realized that proper cleaning is the key to successful metal finishing. As such it is a factor that must figure prominently in the decisions made by those responsible for product design and manufacture.

This article is not intended to be a working manual on metal cleaning, nor is it, in the usual sense, a primer on metal cleaning. Its purpose is simply to familiarize the non-expert with the basic features of the standard metal cleaning methods and to aid him in selecting the method most feasible for a particular application.

With this purpose in mind a tabular presentation has been emphasized. The tables, it is believed, make possible a point-by-point comparison of cleaning methods that cannot easily be achieved in the more conventional type of discussion. On the other hand, the natural limitations of a tabular presentation must not be overlooked—especially, the necessity for condensation.

Selecting the General Method

For the purpose of this article, the standard metal cleaning processes have been grouped into 15 general "methods" and their characteristics are summarized in the six tables on the following pages. Table 1 describes the principle of each method and outlines the main processes used. Table 2 indicates the general range of operating conditions and shows what equipment and utilities are needed for each method. The four remaining tables show the effect of the most important technical variables on the selection of a metal cleaning method. These variables are: the contamination to be removed (Table 3), the metal to be cleaned (Table 4), the size, surface and shape of the part (Table 5), and why the metal is to be cleaned (Table 6).

In using Tables 3 to 6, it is important to realize that an attempt has been made to consider only one factor at a time. In Table 4, for instance, only the limitations imposed by the character of the metal itself are considered. It is believed that this approach may underline the practical characteristics of metal cleaning methods more clearly than the conventional approach which tends to consider all factors together. However, this technique has not been followed too strictly where it seemed to make the presentation too theoretical. For example, where a method might be feasible from the standpont of the one factor being considered, but in practice cannot or would not be selected because of other pertinent factors usually present, terms such as "generally not used", "generally not applicable", etc., have been employed.

Few allusions to production rates and costs appear in the tables. Any of the metal cleaning methods described can, with sufficient investment in both primary and materials handling equipment, be adapted to high production requirements. Much depends on the size and shape of the part and the complexity of the cleaning problem. For this reason it is usually desirable to consider first what cleaning methods are technically feasible and then, where there is a choice, which seems to be best adapted to the level of production required. Similarly, there is little advantage in comparing an inherently low-cost method that is inadequate for the job with a more expensive method that is needed for adequate cleaning. Hence, comparative costs generally should be considered only where more than one method appears technically feasible. Such cost comparisons are usually valid only for a specific part on a specific production line.

How to Use the Tables: An Example

Suppose it is desired to apply a corrosion-resistant metallic plate to the grooves of a polished aluminum piston. An adherent coating requires the prior removal of the natural oxide film as well as greasy polishing and buffing compounds. Since the somewhat specialized techniques for plating on aluminum usually involve oxide removal more or less integral with the plating process, only the removal of organic contaminations will be considered here.

First, refer to Table 1. It is evident that acid pickling, electrolytic acid pickling, blast cleaning, brushing and flame cleaning can be ignored for this case.

Next, refer to the section on polishing and buffing compounds in Table 3. Soak alkali cleaning, electrocleaning barrel cleaning, petroleum spirit cleaning and salt bath cleaning appear to be generally unsuitable, or at least questionable, for this application.

Refer to the section on aluminum in Table 4. The only important limitation on remaining methods appears to concern the possibility of aluminum dust in vapor degreasing. Presumably significant amounts of dust would not be present after final polishing operations.

Next refer to the sections on recesses, close tolerances and high polish in Table 5. In this case, the recesses are not likely to entrap significant amounts of liquid, so the limitations mentioned for soak emulsion cleaning and vapor degreasing do not apply. Acid cleaning appears to be undesirable where retention of high polish is desired. Machine cleaning and steam cleaning seem to be inadequate or difficult where recesses must be cleaned. Thus, the selection has been narrowed to a choice between soak emulsion cleaning and vapor degreasing.

Now see the section on electroplating in Table 6. Still disregarding the necessity for oxide removal, it can be seen that vapor degreasing provides a satisfactory surface prior to plating where the insoluble smut commonly associated with ferrous metals is not present. Emulsion cleaning, on the other hand, must be followed by immersion in a relatively clean alkali or electrocleaning bath. Offhand, it appears that vapor degreasing might be the more economical choice. It may be recalled from Tables 1 and 3 that vapor degreasing would probably require several different stages to remove polishing and buffing compounds.

With this in mind, refer to the sections on equipment, utilities and safety precautions in Table 2. It is evident that even a combination of two soak cleaning methods might possibly be cheaper than a multi-stage vapor degreasing machine, particularly if dip tanks were already available. Certainly, two-stage soak cleaning should be investigated.

Accordingly, refer again to the appropriate sections of Tables 3, 4, 5 and 6 under soak alkali cleaning and electrocleaning. Now that the necessity of removing the polishing and buffing compounds has been removed, it is clear that both methods are suitable for the application providing careful cleaner selection is made. Soak alkali cleaning, of course, is cheaper than electrocleaning and would be preferred if the somewhat cleaner surface resulting from electrocleaning is not considered essential.

Thus, the selection seems to boil down to an economic choice between vapor degreasing alone and emulsion cleaning followed by soak alkali cleaning or electrocleaning. High production rates and limited floor space favor vapor degreasing, low or intermittent production favors soak cleaning. Other influential factors are discussed briefly in the following part of this manual. Generally, when more than one method or process appears to be feasible, it is advisable to consult manufacturers of metal cleaning equipment and supplies to establish the optimum choice.

Selecting the Specific Process

Once it has been decided that a particular cleaning method seems to be the most feasible for a given application, there remains the problem of translating the general method into a specific operating process. This is not always simple. There are usually a great many variables that must be set, and a great amount of time and money can be wasted in trying to establish empirically, from scratch, the optimum operating conditions. Fortunately, the metal cleaning field being what it is, many of these headaches can be avoided by relying upon the expert advice and assistance of one of many reputable companies in the field. Their field service men, after all, have seen hundreds of metal cleaning problems and are usually prepared to recommend a specific process and operating conditions for any normal job. The following section discusses briefly some major factors that must be weighed in determining the optimum process for the most important methods covered in this article:

Chemical Cleaning

A great number of different chemical cleaners are available in proprietary formulations. Cleaners marketed by reputable companies are generally superior to "home-made" cleaners as they are the result of much research and field development. Such formulations are usually compounded to give optimum performance under specific sets of conditions, and it is advisable to consult with the supplier in selecting a particular compound and establishing operating conditions.

Despite the multiplicity of such compounds, a few helpful generalizations can be made. Alkali cleaners, for instance, differ in composition according to the metal on which they will be used and the method by which they will be applied. So-called "heavy duty" cleaners are not suitable for brass, zinc and aluminum; conversely, cleaners suitable for aluminum are generally not used for steel because of their slower cleaning action. Alkali cleaners used in spray washers or in electrocleaning differ from those used in soak tank cleaning in that the proportion of emulsifying agent is reduced to prevent foaming caused by aeration (in the case of spray cleaning) or absorption of gases (in electrocleaning).

Similarly, "emulsion cleaners" is a broad term. In selecting an emulsion cleaner it is important to keep in mind the specific cleaning system to be used and the kind of surface desired. A diphase cleaner, for instance, is not suitable for heavy cleaning unless mechanical agitation is provided. Some proprietary emulsion cleaners are formulated in such a way as to minimize the residual oil film, while others tend to produce a fairly stable film which offers a certain amount of corrosion protection during subsequent fabricating operations.

Acid cleaners, too, are available in many different formulations. Like alkali cleaners, they are compounded for specific metals and methods of application. In addition, the two components of their dual function (cleaning and pickling) can be varied over a wide range depending on the specific requirements of the application.

Where there is some question as to which of these three types of soak cleaning would be most feasible, it should be remembered that alkali cleaners are generally least expensive. The difference in cleaner cost, however, is sometimes offset by the cost of keeping alkali cleaning solutions at boiling temperature.

Machine Cleaning

Where there is a large volume of work, washing machines are often used. Machines of standard design and size can often be used, particularly where parts are relatively small. In many cases, and especially for large parts, a custom-built installation is preferable. In addition to the common spray type machines, there are paddle wheel machines that use a revolving wheel to splash solution on the work and scoop type machines that combine immersion and tumbling. Selection and design of metal washing machines depend not only on the size and quantity of parts, but also on the number of operations to be performed, the materials handling system employed and the type of cleaner to be used.

Ordinarily, both cleaning and rinsing are done in a single machine, and often two or more cleaning stages are incorporated in the machine. A forced drying stage is also widely used. Most washing machines use one of three methods to transport work through the unit: conveyor belt, overhead monorail or a rotating drum with a helix to guide the work forward. All three are suitable for straight line production, but where loading and unloading at the same location is desired, the monorail conveyor is clearly most suitable.

Cleaners for machine washing must be nonfoaming and are used in concentrations much lower than for soak tank cleaning. Economic considerations limit cleaning time which usually ranges between 15 sec and slightly more than 1 min. Despite the mechanical action involved, short contact time, low cleaner concentrations and nonfoaming requirements limit the cleanliness of the surface obtainable from machine cleaning, particularly where heavy or tough organic deposits are present.

Although spray washing has traditionally been an elevated temperature process, some cleaning compounds designed especially for room temperature operation have been developed. One company is now marketing such cleaners that are also claimed to provide a passivated surface durable enough to protect the clean metal from rusting for a period of several weeks.

Solvent Cleaning

The selection of a petroleum spirit cleaner generally rests on cost and availability, as differences in technical performance are relatively insignificant. However, it is also well to consider the flash point and toxicity, as the cost of venting or enclosing a tank can easily outweigh small savings in cost of solvent.

In vapor degreasing, on the other hand, an accurate knowledge of the technical requirements is essential for economical process design. In contrast to soak cleaning methods, vapor degreasing often involves a large capital investment in relatively inflexible equipment. This is especially true where several stages are needed for proper cleaning. In selecting a vapor degreasing cycle it is important to remember that the solvent acts only on oil and grease, and some kind of mechanical action is needed to remove solid contaminations. Where solids are present, therefore, a spray or boiling stage must be used, and this stage should precede ordinary liquid or prolonged vapor immersion. Otherwise, the oils which enclose the dirt and assist its removal would be dissolved away and the hot vapor stage would tend to cake the residual dirt.

Trichloroethylene is the solvent generally preferred for vapor degreasing. Higher-boiling perchloroethylene is more expensive to use and is usually restricted to applications requiring the removal of high-melting waxes or of certain water-bearing contaminants, or the penetration of spot-welded seams or fine orifices.

The ultrasonic technique seems to be particularly well adapted to vapor degreasing. Most of the units now in operation are severely limited by the small effective area of the transducer. Nevertheless, they have been used successfully to remove particularly tough contaminations from crevices and other relatively inaccessible surfaces. Several units recently put in operation utilize a cylindrical transducer immersed in the solvent through which somewhat larger parts can be passed continuously. Further developments

Table I—Principles of Metal Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning
Cleaning Agent	Water solution of alkaline salt and surface-active agents.	1. Emulsifiable solution of hydro-carbon solvents, emulsifying and surface-active agents. 2. Diphase emulsion of hydro-carbon solvent in water (or in alkali cleaning solution).	Water solution of ortho-phosphoric acid, solvent and/or detergent and surface-active agents.	Modified alkali, emulsion, acid or petroleum spirit cleaners with mechanical action.	Modified alkali cleaning solution, liberated gases and polar forces.	1. Alkali, acid or emulsion cleaner, with mechanical action. 2. Grinding chips or metal slugs plus cleaner or abrasive compound, with mechanical action. 3. Dry sawdust, corn cob meal, pegs, etc., with mechanical action.	Alkali or emulsion cleaner with mechanical action.
Principal Contamination Removed	Organic matter and inorganic particles.	Organic matter and inorganic particles.	Organic matter, oxides and metal particles.	Organic matter, inorganic dusts and metal particles.	Organic and inorganic matter.	Organic and inorganic matter, scale, oxides, burrs.	Organic and inorganic matter.
Process	Immersion in hot alkali cleaning solution. One- or two-step spray and/or dip rinse in hot and/or cold water. Sometimes forced drying.	Immersion in hot or cold emulsion, emulsifiable or diphase cleaning solution. One- or two-step spray and/or dip rinse in hot and/or cold water. Sometimes forced drying.	Immersion in hot or cold acid cleaning solution. One- or two-step spray and/or dip rinse in hot and/or cold water. Sometimes forced drying.	Exposure to successive spraying with one or more hot or cold cleaning solutions and cold and/or hot water. Sometimes forced drying.	Immersion as anode, cathode or both (alternately) in current-carrying cleaning solution. One- or two-step spray and/or dip rinse in hot and/or cold water. Sometimes forced drying.	1. Free tumbling in rotating barrel with cleaning solution. Barrel, dip or spray hot or cold water rinse. 2. Free tumbling or fixed rotation in barrel with solid media and abrasive or cleaning solution. Barrel, dip or spray hot or cold water rinse. 3. Free tumbling in rotating barrel with dry solid media. Barrel, dip or spray hot or cold water rinse.	Spraying with cleaning solutions carried by steam jet. Rinsing with steam jet.
Cleaning Mechanism	Displacement, emulsification and (sometimes) saponification of oils which carry with them the other surface contaminations to which they are attached.	Emulsification and solution of oils which carry with them the other surface contaminations to which they are attached.	Emulsification or solution of the oils which carry other contaminations to which they are attached, plus dissolving or undercutting and displacement of oxide films.	Same as in soak cleaning, plus mechanical displacement by impinging liquid.	Same as soak alkali cleaning, plus mechanical displacement by impinging gas, plus polar repulsion of charged dirt particles.	Same as alkali, acid or emulsion cleaning, plus mechanical displacement and cutting by solid media.	Same as soak alkali or emulsion cleaning plus mechanical displacement by impinging liquid and vapor.
Character of Resulting "Clean" Surface	Residual alkali and usually slight traces of organic contaminations. Sometimes slight etch.	Thin oil film and slight traces of organic contaminations.	Slight etch and sometimes thin oil film, with traces of organic contaminations.	See corresponding soak methods. Residual organic contamination usually greater due to short cycle.	Residual alkali. Almost completely free of traces of organic contaminations (when anodic cycle used). Sometimes slight etch.	See corresponding soak cleaning methods. Sometimes slight inorganic contamination. Matte finishes of controllable brightness.	See corresponding soak methods. Residual organic contamination usually greater due to short cycle.

and refinements may be expected to greatly increase the applicability of ultrasonic cleaning.

Electrocleaning

An optimum electrocleaning cycle requires careful attention to a number of factors—particularly the cleaner, the polarity and the current density.

As mentioned previously, alkali cleaners must be specially compounded for electrocleaning to avoid a foam blanket that might result in a gas explosion. They must also be highly ionizable in order to conduct electric current. They should be free of ingredients that might dissociate and attack metals and free of substances that might plate out as smut on the metal.

Cleaning action can be speeded by increasing voltage and current density, since this increases the rate of gas evolution. High current densities, however, tend to produce pitting of nonhomogeneous metal surfaces. Where retention of polished surfaces is desired, immersion times must be minimized, and this usually means an increase in current density. Hence, it is sometimes necessary to achieve a fine balance between etching and pitting tendencies by close adjustment of current density and immersion time.

Cathodic cleaning is theoretically faster than anodic cleaning, as twice as much gas is evolved at the cathode. However, the tendency for smuts to plate on the cathode and the tendency for hydrogen embrittlement make anodic cleaning generally preferable for high-quality cleaning where undesirable anodic films are not formed. It is possible of course, to use both cycles—the anodic cycle being used last to "unplate" the smuts deposited in the cathodic cycle. The two cycles can be used in the same bath, but separate tanks are preferred for high-quality work. Use of both anodic and cathodic polarity in a controlled cycle is known as "periodic reversal" cleaning.

Acid Pickling

The two acids most widely used for pickling are sulfuric and hydrochloric. Hot sulfuric acid is the more popular since it is cheaper; hydrochloric, on the other hand, dissolves scale faster. Hydrochloric acid is seldom heated because of the extreme corrosiveness of its fumes.

Commercial grades of acid are not pure acid but standard dilute solutions. Standard dilute solutions, in turn, are seldom used straight but usually diluted still further. In specifying concentrations, it is important to be sure whether a percentage refers to pure acid or to a commercial grade. It is also important to be familiar with the activity curves of these acid solutions, as activity increases with concentration only in a restricted range of concentrations. Another variable is the

Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
Hydrocarbon solvent sometimes with mechanical action.	Trichloroethylene or perchloroethylene liquid and vapors, sometimes with mechanical action.	Dilute sulfuric, hydrochloric, nitric, hydrofluoric, chromic, citric, etc., acids, sometimes containing inhibitors.	1. Dilute sulfuric acid solution (sometimes containing tin), liberated gases and polar forces. 2. Strongly alkaline solution containing cyanide, liberated gases and polar forces.	Oxidizing and/or reducing agents in molten caustic carrier plus mechanical action and (sometimes) dilute acids as in pickling.	Metallic shot or grit, nonmetallic grit, or water suspension of fine abrasive, with mechanical action.	Wire or fiber brushes (sometimes with abrasive or with water cleaning solutions) with mechanical action.	Heat with mechanical action.
Organic matter.	Organic matter.	Oxides, scale, rust.	Scale, rust, oxides. Sometimes organic and inorganic matter (alkali process).	Scale, oxides, organic and inorganic matter.	Scale, inorganic matter, burrs.	Scale, organic and inorganic matter, burrs.	Scale.
1. Immersion in or spraying with cold solvent. Forced drying. 2. Hand wiping with cold solvent-saturated rags. Drying by hand wiping with dry rags.	Immersion in solvent vapor, often succeeding prior immersion in boiling liquid, warm liquid, cool liquid or spray or several such stages. Tranducer emitting ultrasonic vibrations sometimes included in liquid stage.	Immersion in hot sulfuric, cold hydrochloric or other acids. Dip or spray cold water rinse.	1. One- or two-step immersion as cathode in current-carrying hot sulfuric acid solution (sometimes containing tin). Dip or spray cold water rinse. 2. Immersion as cathode, anode, or both alternately, in warm alkali bath. Two-step spray and/or dip rinse in cold and/or hot water.	1. Immersion in molten salt bath. Cold water quench-rinse. Short acid pickling or brightening cycle. 2. Immersion as cathode and/or anode (alternately) in current-carrying molten salt bath. Cold water quench-rinse.	1. Exposure to stream of propelled metallic shot or grit, or nonmetallic grit. 2. Exposure to stream of water-suspended abrasive. Dip or spray hot or cold water rinse.	1. Contact with rotating or manually operated wire or fiber brushes. 2. Contact with rotating fiber or fine wire brushes charged with abrasive. 3. Contact with rotating brushes preceded by immersion in water or cleaning solutions.	Contact with flame and heat of oxyacetylene torch.
Solution of the oils which hold other contaminations on surface, plus (sometimes) mechanical displacement by manual wiping or spraying.	Solution of the oils which hold other contaminations on surface, plus (sometimes) mechanical displacement by impinging liquid and/or ultrasonic vibration.	Dissolving or undercutting of oxides.	1. Acid processes: same as Acid Pickling, plus mechanical displacement by generated gas. 2. Alkali process: similar to Electrocleaning but without emulsification, plus oxidation and/or reduction, plus dissolving or undercutting of oxides.	Oxidation and/or reduction, plus mechanical displacement by thermal shock and steam during rinse, plus (sometimes) dissolving or undercutting of oxides, residual scale.	Cutting and/or loosening by shock of impact plus mechanical displacement and peening by impinging solids or liquids.	Mechanical displacement by impinging mass through cutting or peening.	Cracking and loosening of scale caused by rapid uneven rise in temperature and different coefficients of thermal expansion.
Slight traces of organic contaminations.	Sometimes traces of solvent stabilizers.	Slight to deep etch. Residual traces of metal salts and pickling inhibitors.	1. Acid process: same as Acid Pickling. Sometimes tin deposit. 2. Alkali process: Residual alkali. Sometimes slight etch. Almost no traces of organic contaminations.	Sometimes slight etch, residual traces of metal salts and pickling inhibitors from acid dip.	Matte finish of controllable brightness and fineness.	Finish controllable from mirror to coarse satin (where wire or abrasive-loaded brushes used). See corresponding soak methods where cleaner used.	Sometimes small patches of tightly adhering scale and larger patches of loosely adhering scale.

effect of build-up of metallic salts. A build-up of ferric sulfate, for instance, gradually weakens the strength of a sulfuric acid bath, whereas a build-up in ferric chloride increases pickling strength in a hydrochloric acid bath.

Use of a pickling inhibitor is more and more common today. Action of the inhibitor is to prevent attack of the base metal without inhibiting attack on the scale. This, of course, reduces pitting and metal loss and saves acid. The growing pressure for in-plant waste disposal and its high cost have led to broad acceptance of inhibitors despite their relatively high price.

Other acids are used for special purposes. More costly phosphoric acid, for instance, can be used where a whiter surface free of carbide smut is desired on steel. Chromic acid and salt mixtures are widely used on magnesium to provide both cleaning and a protective film. Citric acid is sometimes used to avoid galvanic effects where dissimilar metals are in contact.

Salt Bath Cleaning

In selecting a salt bath cleaning or descaling process it is necessary to consider the advisability of oxidizing action versus reducing action and of electrolytic versus non-electrolytic operation. Electrolytic operation, of course, makes it possible to use both oxidizing and reducing alternately. The sodium hydride bath is a reducing process, whereas the non-electrolytic Hooker and Kolene processes are oxidizing.

Another important consideration is temperature. Generally, the sodium hydride process operates around 700 F and the others operate in the 800 to 1000 F range. Such high temperatures sometimes make it feasible to combine the cleaning operation with heat treating. In such a case, the heat treat temperature desired might determine the process to be used.

The short acid dips following the water quench are generally independent of the type of salt bath used, provided it has been effective. Marketers of salt bath processes can recommend complete cycles for most types of applications.

Blast Cleaning

One of the most important variables that must be considered in dry blast cleaning is the type and size of shot or grit used. To some extent this choice is dependent upon the character of the metal surface and the type of finish desired. Thus, the larger sizes would not be used where a relatively fine finish is desired. Cast iron or malleable grits would be used where a brighter finish than that produced by shot blasting is desired, and brass turnings or nonmetallic grits might be used on the softer nonferrous metals.

(Continued on page 134)

Table 2—Requirements of Metal Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning
Cleaner Concentration	4-12 oz/gal.	10-100% by volume.	5-50% by volume.	½-2 oz/gal (alkali) ½-5% by volume (emulsion), ½-20% by volume (acid).	4-16 oz/gal.	1-4 oz/gal (alkali or acid), ½-5% by volume (emulsion).	½-4 oz/gal (al[kali]), ½-5[%] by volum[e] (emulsion).
Temperature	140 F to boiling (212 F), depending on metal.	Room to 160 F, depending on flash point of solvent.	Room to 160 F.	Room to 160 F.	140-212 F.	Usually room. Sometimes to 180 F.	280-370 F.
Other Operating Conditions	Agitation: maximum feasible.	Agitation: maximum feasible.	—	Liquid pressure: 10-100 psi (usually 20-30 psi).	Voltage: 3-12 v. Current density: 20-100 amp/ft². Polarity: anodic and/or cathodic.	Barrel speed: about 200 surface ft/min or 20 rpm for 36-in. barrel. Ratio media/load: 1-1 to 10-1.	Steam pres[s]ure: 50-15[0] psi (usuall[y] wet).
Equipment Needed	Open tank with heating coils or immersion heater. Overflow rinse tank, spray with pumps, or hose. Optional: heating coils in rinse tank; agitator drier.	Open tank. Spray with pumps, hose or overflow rinse tank. Optional: heating coils; agitator (sometimes compressed air); drier.	Acid-resistant open tank. Overflow rinse tank, spray with pumps, or hose. Optional: heating coils; agitator (sometimes compressed air); drier.	Closed machine with pumps, automatic handling system. Optional: heating coils.	Open tank with electrode plates, bus bars and heating coils. Overflow rinse tank, spray with pumps or hose. Optional: heating coils in rinse tank; periodic reversal equipment.	Mounted horizontal or tilt hexagonal or octagonal barrel with motor drive. Overflow rinse tank, spray with pumps, or hose. Optional: heating coils in rinse tank; separating screens; centrifugal drier; steam jacket on barrel.	Hose with spe[-]cial nozzle steam gener[a]tor, containe[r] for cleanin[g] solution.
Utilities Needed	Water. Gas, oil, electricity or 15-30 psi steam.	Water. Optional: 10-15 psi steam.	Water. Optional: 10-15 psi steam.	Water, electricity. Optional: gas or 15-30 psi steam.	Water. Gas or 10-30 psi steam. Low voltage direct current.	Water, electricity. Optional: 10-15 psi steam.	See above.
Special Safety Precautions Needed	Some caution required by personnel handling hot alkali solutions.	Open flame in vicinity of tank must be avoided because of inflammable nature of fumes from some solutions.	Some caution required by personnel handling dilute acid solutions.	Precautions same as for corresponding soak cleaning methods. Control of sprayed solvent particularly important because of inflammability.	Some caution required by personnel handling hot alkali solutions.	See corresponding soak cleaning methods. Rotating barrel should be guarded by screens for safety of personnel and vented to prevent pressure build-up.	Normal pre[-]cautions re[-]quired in hand[-]ling live stea[m] and hot clean[-]ing solution[s]. Protectiv[e] clothing, goo[d] ventilatio[n] needed.

Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
100%.	100%.	½-15% (sulfuric), ½-50% (hydrochloric), 10-50% (nitric), 1-10% phosphoric, 3 oz/gal (citric). Also proprietary dry salts in various concentrations.	1. 10% sulfuric acid (Bullard-Dunn). 10-20% and 40-50% sulfuric acid (Hanson-Van Winkle-Munning). 2. 1-3 lb./gal alkalicyanide compound (Enthone).	1½-3% active reducing agents (sodium hydride) or up to 100% oxidizing agents (Virgo, Kolene).	—	—	—
Room.	Room to boiling (188 F for trichloroethylene, 250 F for perchloroethylene).	Room to 180 F, depending on acid.	Room (H-V-W-M); 150 F (B-D); Room to 120 F (Enthone).	700 F (sodium hydride) to 800-1000 F (Virgo, Kolene).	Room.	Room.	1500-2000 F (metal temperature).
—	—	—	Voltage: 4-15 v. Current density: 60 amp/ft² (B-D); 100-150 amp/ft² (H-V-W-M); 5-500 amp/ft² (Enthone). Polarity: cathodic (B-D); both (H-V-W-M); anodic and/or cathodic (Enthone).	Kolene No. 4 only: anodic and/or cathodic, up to 6 volts, 10-150 amp/ft².	Airblast: 10-100 psi nozzle air pressure. Wheelblast: 2000-2500 rpm wheel speed; 15-20 h.p. input; adjustable impact pattern.	Brush speeds (normal range): 5500-9000 surface ft/min (wire); 4000-7500 sfpm (non-metallic); 1000-3000 sfpm (wet).	—
Open tank, safety can or wipe-on facilities. Good ventilation required. Fire extinguisher advisable.	Deep open tank or (usually) canopied machine, both with heating and cooling coils. Optional: spray pumps, ultrasonic unit, separate solvent recovery system.	Acid resistant open tank. Fume hood. Overflow rinse spray tank, with pumps, or hose. Optional: heating coils.	Acid- or alkali-resistant open tank with electrode plates, bus bars. Overflow rinse tank, spray with pumps or hose. Optional: heating coils, periodic reversal equipment, tin stripping bath.	Gas-fired tank or special immersed electrode salt bath furnace. Water quench tank. One or more acid-resistant open tanks. Overflow rinse tank, spray with pumps, or hose. Optional: electrode plates, bus bars.	Air blast gun with compressor, liquid blast cabinet, or air- or wheel-blast machine or "room". Optional: overflow rinse tank, spray with pumps, or hose.	Brush drive with arbor or spindle size sufficient to avoid excessive deflection or vibration and power sufficient to avoid excessive slowdown under load. Optional work holder for accurate positioning; dust collector.	Oxyacetylene torch, gas cylinders.
None.	10-15 psi steam (for trichloroethylene) or 50-60 psi steam (for perchloroethylene). Water.	Water. Optional: gas or 10-15 psi steam.	Water. Low voltage direct current. Optional: gas or 10-15 psi steam.	Water, gas or electricity. Optional: low voltage direct current.	Electricity. Optional: water, compressed air.	Electricity or compressed air.	None.
Open flame, sparks, static electricity, heat concentrations, etc., in vicinity of tank must be avoided because of inflammable nature of solution and vapors.	Specially designed unit with balanced heating and cooling capacity needed to control solvent losses and exposure to toxic vapors.	Normal precautions against acid burns must be observed. Fumes must be vented, particularly where bath is heated. Acid-resistant equipment needed in contact with fumes.	Acid processes: see Acid Pickling. Alkali process: some caution required by personnel handling salts or solution.	Contact between water and caustic bath must be avoided because of hazardous spattering. Normal precautions against skin burns from hot caustic must be observed.	Protective rubber gloves needed in manually operated units. Face masks needed where silica used.	Rotating brushes should be guarded by housings for safety of personnel. Goggles for operator. Dust collectors needed in removal of fine encrustations.	Normal precautions required in handling gases and flame.

Table 3—How Surface Contaminations Affect Selection of Metal Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning	Petroleu Spirit Clea
Molding Sand	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Both dry and wet (sometimes with hydrofluoric acid) processes widely used.	Not applicable.	Not applica
Free Graphite, Carbon, Carbon Smut	Sometimes suitable.	Graphite can sometimes be removed with undiluted' emulsifiable solvent and spray rinse.	Not applicable.	Sometimes suitable with alkali cleaner.	Carbon smut can be removed by anodic or periodic reversal cleaning.	Suitable for free graphite.	Not applicable.	Not applica
Mill, Forging, Heat Treat and Weld Scale	Not applicable.	Not applicable.	Generally not applicable except for light scale.	Not applicable.	Not applicable. See Electrolytic Pickling (alkali process).	Wet tumbling widely used, usually with acid cleaners.	Not applicable.	Not applica
Inorganic Soldering Brazing and Welding Fluxes	Special cleaners can sometimes be used.	Not applicable.	Sometimes used.	See soak alkali cleaning.	Not applicable.	Wet tumbling OK.	Not applicable.	Not appli
Lubricants Coolants, Other Oils and Greases	Widely used and quite satisfactory even for thick coatings not coning many solid contaminations.	Widely used, especially where oil films contain solid contaminations.	Can be used on thin films but generally not used except where oxide removal also desired.	Widely used with alkali or emulsion cleaners.	Widely used. Not recommended for saponifiable oils.	Wet tumbling often used on small parts. Dry tumbling with absorbent, expendable media also used.	Can be used when other factors make this method advantageous.	Dipping used fo coatings. requir heavy c especiall solid con tions.
Pigmented Drawing Compounds, Polishing and Buffing Compounds	Sometimes used, but often not suitable alone.	Widely used. Diphase cleaners generally most rapid.	Sometimes used, but often not suitable alone.	Widely used with diphase cleaner.	Can be used after precleaning stage. Not generally used alone because bath loads up too much to provide the exceptionally clean surface usually needed to justify cost of this method.	Wet tumbling sometimes used on small parts.	Can sometimes be used with emulsion or alkali cleaner.	Can be u hand wi
Caked-on Oils and Compounds	Sometimes used, but usually not suitable alone.	Widely used. Relatively long immersions sometimes needed. Diphase cleaners generally most rapid.	Sometimes used, but usually not suitable alone.	Widely used with diphase cleaner.	See above.	See above.	See above.	Genera suitable as presc
Shop Dust, Abrasive Grains, Metal Dust and Chips (alone)	Sometimes used, but generally not needed.	Not needed.	Sometimes used but generally not needed.	Sometimes used but generally not needed.	Not needed.	Not needed.	Not needed.	Widely low pro
Oxides, Rust	Not applicable.	Not applicable.	Widely used for light oxide films, especially where light oil films also present.	Sometimes used with acid cleaner.	Not applicable. See Electrolytic Pickling (alkali process).	Wet tumbling with acid cleaner OK. Dry tumbling suitable for rust.	Not applicable.	Not ap
Paint	Hot alkali strippers widely used to loosen oil-base paints.	Can be used to strip certain types of synthetic resin finishes.	Generally not applicable.	Generally not applicable.	Not applicable.	Limited use.	Widely used alone or with alkali cleaner or special stripper.	Can be us move ened c ishes.
Burrs	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Widely used.	Not applicable.	Not a
Water	OK.	Cleaning effectiveness sometimes lowered.	OK.	See corresponding soak cleaning methods.	OK.	OK. Dry tumbling often used to dry parts.	OK.	Not u

Steam Cleaning	Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
t appli- e.	Not applicable.	Not applicable.	Hydrofluoric acid sometimes used to remove residual burnt-in sand.	Generally not applicable.	Several baths, notably sodium hydride, Kolene No. 4 (reducing) and Virgo Molten Cleaner used, sometimes as more thorough supplement to blast cleaning.	Metallic shot or grit blasting widely used.	Long trim wire brushes can be used.	Not applicable.
t appli- e.	Not applicable.	Not applicable.	Not applicable. Carbon smut sometimes produced by pickling of steel.	Anodic acid process sometimes OK. Anodic or periodic reversal alkali process can be used.	Several baths used, notably Virgo Molten Cleaner and Kolene No. 1, 4 (oxidizing) and 5.	Not applicable.	Short trim wire brushes can be used.	Can be used but heat effects generally not desired.
appli- e.	Not applicable.	Not applicable.	Widely used, sometimes with inhibitors.	Acid processes save up to 80% or more of time needed to remove particularly tough scales by conventional acid pickling. Alkali process, usually with periodic reversal used where no attack on metal desired.	Sodium hydride, Virgo Salt, Kolene No. 1 and 4 (reducing) processes used to remove mill, forge and heat treat scale. Cycles usually much shorter than straight pickling for tough scales.	Metallic shot or grit blasting widely used to remove heavy scales. Wet blasting sometimes suitable for very light scales.	Heavy wire brushes used on mill scale after breaking. Knot type wire brush (12-16 in. dia.) OK for forging, weld and heavy heat treat scale. Treated tampico brush with abrasive OK for light heat treat scale or heat tint.	Especially suitable for heavy scales.
appli-	Not applicable.	Not applicable.	Widely used.	Generally not applicable.	Often suitable in conjunction with descaling.	Widely used.	Wire brushes used (short trim for soft flux, knot type for hard). Flexible fiber brushes in water used for soluble flux.	Not applicable.
be used other 's make method tageous.	Dipping can be used for light coatings. Wiping required for heavy coatings, especially with solid contaminations.	Widely used. Light coatings may require only vapor cycle whereas heavy coatings may require boiling solvent or spray stages.	Not applicable.	Acid processes not applicable. Alkali process suitable for light cleaning in conjunction with oxide removal.	Oxidizing baths remove organic contaminations but are generally uneconomical except for heavy deposits or in conjunction with descaling.	Shot not used as it becomes loaded. Blasting with inexpensive (expendable) nonmetallic grits sometimes used.	Generally not used as brush becomes loaded.	Not applicable.
metimes ed with on or al- eaner.	Can be used with hand wiping.	Widely used. Spray and/or boiling solvent stages needed.	Not applicable.	See above.	See above.	See above.	Fiber brushes in emulsion cleaners can be used.	Not applicable.
ove.	Generally not suitable except as presoak.	Sometimes suitable as presoak or after emulsion presoak.	Not applicable.	See above.	See above.	See above.	Flexible wire brushes can be used.	Not applicable.
eded.	Widely used in low production.	Not needed.	Not applicable.	Not applicable.	Not needed.	Not needed.	Untreated fiber brushes at low speeds widely used.	Not applicable.
ppli-	Not applicable.	Not applicable.	Widely used.	Generally not economical for light oxide films. Cathodic alkali process used for rust where other cleaning also desired.	Generally not economical for light oxide films, but sometimes used where no surface etch desired.	Metallic grit or sand blasting widely used.	Wire brushes widely used to remove rust. Treated fiber brushes with abrasive used for light oxides.	Not applicable.
used r with leaner l strip-	Can sometimes be used to remove unhardened organic finishes.	Not applicable.	Not applicable.	Acid processes not applicable. Alkali process can be used where oxide removal also desired.	Oxidizing baths, notably Virgo Molten Cleaner and Kolene No. 1, 4 and 5, can be used.	Metallic grit or sand blasting widely used.	Flexible long-term wire or abrasive-loaded fiber brushes can be used.	Widely used.
ppli-	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Metallic shot or grit blasting widely used for light burrs.	Short-trim dense wire brushes (0.005-0.014 in. wire dia.) used. Treated fiber brushes with abrasive used for fine finishes.	Not applicable.
	Not used.	Not used.	OK.	OK.	Not used.	Wet blasting OK.	Wet brushing OK.	OK.

Table 4—How Metals Affect Selection of Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning	Petroleu[m] Spirit Clea[ning]
Malleable, Ductile and Gray Cast Iron	OK	OK	Sometimes slight pitting caused by uneven etching of metallic and nonmetallic phases.	See corresponding soak cleaning methods.	Anodic cycle tends to cause localized attack.	OK	OK	K
Carbon and Alloy Steel	OK	OK	OK	OK	OK	OK	OK	K
Stainless Steel	OK	OK	OK	OK	OK	OK	OK	K
Copper	OK. Special inhibited types of cleaners sometimes needed to prevent chemical attack.	OK	OK	See corresponding soak cleaning methods.	See soak alkali cleaning. Strong alkali cleaners can be used in cathodic cycle.	Careful cleaner selection and process control needed to prevent staining or excessive abrading of non-ferrous metals. Dry tumbling often used on copper.	See soak alkali cleaning and spray cleaning.	K
Brass and Bronze	Special inhibited types of cleaners must be used to prevent chemical attack.	OK	OK	See corresponding soak cleaning methods.	See soak alkali cleaning. Anodic cleaning requires low current density, short immersion to prevent dezincification.	See above and corresponding soak cleaning methods.	See soak alkali cleaning.	OK
Zinc	See above. Cleaner inhibition more critical for zinc than for brass.	OK	Dilute solution OK.	See corresponding soak cleaning methods.	Strongly inhibited cleaner needed to prevent formation of anodic film (although anodic film sometimes desirable protection prior to further finishing). Short immersion, low current density and temperature (140-160 F) used.	See above and corresponding soak cleaning methods.	See soak alkali cleaning.	OK
Aluminum	See above. Cleaner inhibition more critical for aluminum than for zinc.	Usually OK but some types of cleaners may attack metal.	Dilute solution OK. Some alloys may develop copper or silicon smut.	See corresponding soak cleaning methods.	Anodic cleaning not used because of film formed; cathodic cycle sometimes used.	See above and corresponding soak cleaning methods.	See soak alkali cleaning.	OK
Magnesium	OK	See above.	Seldom used. See Acid Pickling.	See corresponding soak cleaning methods.	Cathodic cycle often used.	OK	Not generally used as steam attacks magnesium.	OK
Tin	Special inhibited types of cleaners must be used to prevent chemical attack.	See above.	Special cleaners sometimes used to remove tarnish.	See corresponding soak cleaning methods.	Short cathodic cycle can be used with mild cleaner.	Dry tumbling sometimes used for cleaning.	OK with specially designed cleaners.	OK
Lead	See above.	See above.	Not used.	See corresponding soak cleaning methods.	See above.	Dry tumbling sometimes used for cleaning.	See above.	OK
Nickel	OK	OK	Not used.	See corresponding soak cleaning methods.	Cathodic cycle OK.	OK	OK	OK
Titanium	OK	OK	Not used.	See corresponding soak cleaning methods.	Cathodic cycle OK.	Not used on pure metal.	OK	OK

Steam Cleaning	Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
	K	OK	Tendency for pitting caused by uneven etching of metallic and nonmetallic phases.	See Acid Pickling. Alkali process OK.	Reducing baths OK. Oxidizing baths OK if removal of surface graphite or carbon permitted.	OK	OK	OK
	K	OK	OK	OK	OK	OK	OK. More ductile grades require shorter trim in wire brushes.	OK
	K	OK	Hot sulfuric or hydrochloric acid, followed by nitric-hydrofluoric acid, widely used. Long immersions sometimes needed.	Acid processes OK. Alkali process generally not satisfactory.	Electrolytic process requires precautions to prevent undesirable galvanic effects.	Nonmetallic abrasive used to prevent contamination by embedded particles. Usually followed by nitric acid dip for passivating.	Fiber brushing OK. Wire brushing preferably done with stainless steel wire to avoid possible electrolytic corrosion resulting from embedded particles.	OK
ak alkali ing and r clean-	K	OK	Acid concentrations generally limited to ½-5% sulfuric, ½-10% hydrochloric, 1-5% phosphoric.	Not applicable.	OK. Dip in dilute sulfuric acid containing sodium dichromate used in descaling.	Sand or copper shot OK. Ferrous shot and grit generally not used as they tend to embed articles in surface.	OK	Not used.
ak alkali ng.	K	OK	See above.	Not applicable.	OK. See above.	See above.	OK	Not used.
k alkali g.	K	OK. Presence of zinc dust must be avoided as it tends to promote breakdown of solvent, producing hydrochloric acid.	Only brief cycles in dilute acid used.	Not applicable.	Not used as bath temperatures too high.	Sand used with low blast pressures. Ferrous shot and grit generally not used as they tend to embed particles in surface.	Fiber brushes preferred.	Not used.
alkali	OK	OK. Presence of aluminum dust must be avoided as it tends to promote breakdown of solvent, producing hydrochloric acid.	Nitric-hydrofluoric acid used, especially to clean as-cast surfaces.	Not applicable.	Not used.	Nonmetallic abrasives used.	OK but embedded particles from wire brushing must be removed to prevent staining.	Not used.
nerally steam mag-	OK	OK. Presence of magnesium dust must be avoided as it tends to promote breakdown of solvent, producing hydrochloric acid.	Chromic acid-nitrate, chromic-nitric-hydrofluoric acid and chromic acid solutions most widely used. Phosphoric, sulfuric and acetic-nitrate baths also used.	Not applicable.	Not used as metal reacts vigorously with bath.	See above. Must be followed by acid pickling if maximum corrosion resistance desired. Close dust control particularly important to prevent explosions.	See above. Close dust control particularly important to prevent explosions.	Not used.
spe- igned	OK	OK	Fluoboric acid used.	Not applicable.	Not used as bath temperatures too high.	Metallic shot and grit not used as metal too soft.	Fiber brushes sometimes used.	Not used.
.	OK	OK	Sulfuric acid-fluoride or fluoboric acid used.	Not applicable.	See above.	See above.	Not used.	Not used.
	OK	OK	OK	Cathodic cycles OK.	OK with dilute nitric acid dip.	OK	Abrasive-loaded fiber brushes OK.	Not used.
	OK	OK	Sulfuric acid effective for light scales. Hot fluoboric acid, hydrofluoric acid and nitric-hydrofluoric acid effective for heavy scales, but salt bath descaling generally recommended.	Not applicable.	Sodium hydride, Virgo and Kolene processes effective with nitric-hydrofluoric acid dip. Temperature of some baths must be closely controlled as metal often reacts with caustic above 900 F.	OK	OK with flexible fine wire brushes.	Not used.

Table 5—How Design Factors Affect Selection of Metal Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning
Fillets	OK	OK	OK	OK	OK	Media must be small enough to contact fillet surface.	OK
Sharp Edges and Corners (to be Retained)	OK	OK	Limited to short immersion times.	OK	OK if current density in anodic cycle not too high.	Not used because tumbling action tends to round all edges.	OK
Threads	OK	OK	See above.	OK	See above.	Media must be small enough to contact thread roots. Close process control needed to prevent damage to threads. Crowns rounded.	OK
Tubing, Cored Holes	Solution agitation usually needed for thorough cleaning of interior surfaces.	See soak alkali cleaning.	See soak alkali cleaning.	Careful positioning of part or use of auxiliary spray needed.	Special electrodes usually needed.	Generally inadequate because of inaccessibility of internal surfaces to media.	Careful positioning of nozzle or part needed.
Recesses, Blind Holes	See tubing. Careful rinsing needed to prevent excessive carryover of cleaner which might lower efficiency of other solutions.	See soak alkali cleaning. Also, cost of solvents make carryout losses expensive.	See soak alkali and emulsion cleaning. Careful rinsing also necessary to prevent deep etching.	See corresponding soak cleaning methods. Careful positioning of part or use of auxiliary spray needed.	See soak alkali cleaning. Also see above.	See soak alkali cleaning. Media must be small enough to contact internal surfaces, and must be emptied out.	See above.
Thin Sections	OK	OK	OK, but limited to short immersion times.	OK	OK	Cannot be used for fragile parts or large unsupported surfaces.	OK if pressure not too high.
Very Small Parts	Rotating baskets or barrels often needed to prevent nestling of small parts. Thorough rinsing needed as parts in contact form recesses.	See soak alkali cleaning.	See soak alkali cleaning.	See soak alkali cleaning. Accessibility of surfaces even further limited in spray cleaning.	See soak alkali cleaning. Effects of electric current limited to parts at surfaces of baskets.	Widely used.	Economically not justified.
Very Large Parts	Large parts awkward and sometimes impossible to handle in practical size tanks.	See soak alkali cleaning.	See soak alkali cleaning.	Widely used for large parts, especially those adapted to monorail conveyor handling.	See soak alkali cleaning.	Limited by barrel sizes. Uneconomical except where considerable deburring and finishing to be done.	Widely used.
Large Fabricated Assemblies	Not applicable.	Not applicable.	Not applicable but wipe-on, wipe-off procedure sometimes used.	Not applicable.	Not applicable.	Not applicable.	Widely used.
Small Perforations, Crevices	Sometimes inadequate.	Sometimes inadequate.	Often inadequate.	See corresponding soak cleaning methods.	Sometimes inadequate.	Often inadequate.	Sometimes used.
Close Tolerances (to be Retained)	OK	OK	OK if immersion times controlled properly.	OK	OK if anodic current density minimized for nonferrous metals.	Generally not used because of rounding action of chips. Can be used with careful process control. Often used to produce precise radii.	OK
Highly Polished Surface (to be Retained)	Immersion times must sometimes be limited on nonferrous metals.	Usually OK except for some nonferrous metals. See Table 4.	Not used because of etching.	Usually OK except for acid cleaning.	Cathodic cycle OK. Anodic cycle OK if operating conditions set for minimum immersion times on nonferrous metals.	Buffed finish cannot be retained. Fairly high polish can be retained on hard but not soft metals. Finish can sometimes be protected by masking or improved by burnishing.	OK

Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
OK	OK	OK	OK	OK	Shot radius must be less than fillet radius.	Brushes with small diameter or high cushion needed to contact surface.	OK
OK	OK	Limited to short immersion times.	OK	OK	Shot blasting not used because shot tends to round all edges.	Control of rotation direction and/or masking needed.	OK
OK	OK	See above.	OK, with short immersion times. Alkali process OK. Acid processes OK. Acid processes OK with short immersion.	OK	Fine grit blasting often OK.	Flexible fill needed to reach thread roots.	OK
Solution agitation usually needed for thorough cleaning of interior surfaces. Wiping not applicable.	OK	Solution agitation usually needed for thorough descaling of interior surfaces.	Inside electrode generally needed.	Solution agitation usually needed for thorough cleaning of interior surfaces.	Carefully positioned airblast nozzle needed for surfaces inaccessible to ricocheting shot.	Specially designed cylindrical brushes can be used.	Not applicable.
See soak alkali and emulsion cleaning.	Good penetration. High cost of chlorinated solvents makes carryout losses often prohibitive unless suitable materials handling equipment provided.	See above. Thorough rinsing needed to prevent deep etching by acid carried over.	OK for shallow recesses. Thorough rinsing needed.	Careful rinsing after acid dips needed to prevent deep etching. Cost of salt bath makes carryout losses expensive.	See above. High costs of some shots such as steel, malleable iron and cut wire, makes carryout losses often prohibitive.	Specially designed end-type brushes can be used.	OK for shallow recesses.
OK	Straight vapor cycle inadequate for heavily oiled surface as it reaches vapor temperature too quickly. Cool solvent dip or spray prior to vapor stage needed.	Immersion times limited.	Alkali process OK. Acid immersion times limited.	Care in handling required to prevent warping or buckling of sheet at bath temperature.	Low impact and fine abrasive needed to minimize warping of unsupported thin sections.	Brushes with high degree of cushion needed.	Danger of warping or buckling of unsupported sections.
See soak alkali cleaning.	Widely used because of good penetration.	Nestling of small parts in baskets limits accessibility of surface bath. Thorough rinsing needed as parts in contact form recesses.	See Acid Pickling and Soak Alkali Cleaning. Plating type barrel can sometimes be used.	See Acid Pickling.	Shot or grit blasting in barrel widely used.	Generally not economically justified.	Not applicable.
Large parts awkward and sometimes impossible to handle in practical size tanks.	Large parts awkward and sometimes impossible to handle in practical size machines or tanks.	Large parts awkward and sometimes impossible to handle in practical size tanks.	See Acid Pickling.	See Acid Pickling.	Air- or wheel-blast "rooms" widely used. Special machines custom-built for high production.	OK	OK
Dipping not applicable. Hand wiping sometimes used.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Airblast room or portable sand-blast unit widely used.	Not applicable except where brushes can be mounted on portable tools.	Not applicable.
Sometimes inadequate.	Good penetration. Spray and/or ultrasonic stages needed.	Sometimes OK.	Sometimes OK for descaling and oxide removal only.	OK	OK if surfaces adequately supported.	Flexible brushes of not too high face density can be used.	Not applicable.
OK	OK	Need strong inhibition. Often not applicable.	Alkali process OK. Acid processes often not applicable.	OK	Wet blasting often used. Shot blasting usually not applicable.	OK	Not applicable.
OK	OK	Not applicable.	Cathodic alkali process OK. Acid processes not applicable.	Not applicable.	Soft nonmetallic grits can be used.	Can be used adjacent to highly polished surface.	Not applicable.

Table 6—How Subsequent Fabricating Operations Affect Selection of Metal Cleaning Methods

	Soak Alkali Cleaning	Soak Emulsion Cleaning	Soak Acid Cleaning	Machine Cleaning	Electro-cleaning	Barrel Cleaning, Tumbling	Steam Cleaning
Phosphate Coating	Widely used with acdiulated rinse.	Widely used.	Can be used as part of multiple-stage phosphatizing process.	Widely used.	Generally not used.	OK	Sometime used.
Painting, Enamelling, Lacquering	Widely used. Acidulated rinse desirable.	Used where residual oil film not detrimental to adhesion. Acidulated rinse generally recommended. Widely used for heavy cleaning prior to alkali cleaning.	Widely used.	Widely used, particularly with acid cleaners. See corresponding soak cleaning methods.	See above.	OK. See corresponding soak cleaning methods where applicable.	Sometime used with di lute phosphori acid rinse o large equip ment.
Vitreous Enamelling	Widely used prior to acid pickling or blasting.	Can be used prior to alkali cleaning.	Not used.	See corresponding soak cleaning methods.	See above.	OK. See corresponding soak cleaning methods where applicable.	Usually no applicable.
Electroplating	Widely used prior to brief acid pickling cycle. Clean bath needed. Also used for heavy cleaning to electrocleaning.	Can be used for heavy cleaning prior to alkali cleaning or electrocleaning.	Not used.	Widely used for heavy cleaning prior to electrocleaning.	Widely used prior to brief acid pickling cycle. Clean bath needed.	Can be used prior to brief acid pickling cycle. Clean barrel needed.	Usually no applicable.
Metallizing	Can be used prior to blast cleaning.	Can be used prior to blast cleaning.	Generally not needed.	See corresponding soak cleaning methods.	Can be used prior to blast cleaning.	Can be used in special metallizing procedures.	Can be used prior to blas cleaning.
Hot Dip Coating	Can be used prior to acid pickling.	Can be used for heavy cleaning prior to alkali or acid cleaning.	Generally not used.	See corresponding soak cleaning methods.	Can be used prior to acid pickling.	OK prior to acid pickling but usually not applicable.	Usually no applicable.
Inspection	Widely used. Corrosion protection afforded by some special proprietary compounds.	Widely used and often desirable when residual oil film is sufficient for temporary corrosion protection.	OK	Widely used. See corresponding soak cleaning methods.	OK but usually used only where exceptionally fast cleaning desired.	Limited use.	OK. No corro sion protec tion.
Welding, Brazing, Soldering	Widely used.	Can be used prior to alkali or acid cleaning.	OK	Widely used. See corresponding soak cleaning methods.	See above.	Widely used.	OK
Heat Treating	Widely used.	OK	OK	Widely used.	See above.	OK	OK
Machining	OK. Corrosion protection afforded by some special proprietary compounds.	OK and often desirable when residual oil film is sufficient for temporary corrosion protection.	OK	See corresponding soak cleaning methods.	See above.	OK	OK. No corro sion protec tion.

Steam Cleaning	Petroleum Spirit Cleaning	Vapor Degreasing	Acid Pickling	Electrolytic Pickling	Salt Bath Cleaning, Descaling	Blast Cleaning	Brushing	Flame Cleaning
metim d.	Can be used for heavy cleaning prior to alkali or acid cleaning.	OK	Can be used for descaling where needed but not required for light oxide removal.	See acid pickling. Used only where rapid removal of thick or tough scales desired.	OK	OK	OK	OK if supplemented by brushing, blasting or pickling.
metim l with phosphor l rinse ge equip t.	See above.	Widely used.	Brief cycle can be used to remove particles embedded by blast cleaning or used alone to roughen surface.	See above.	Can be used in place of straight acid pickling. Thorough rinsing and dilute phosphoric acid rinse needed.	Widely used to produce roughened surface that promotes good adhesion. Sometimes followed by acid pickling or salt bath cleaning.	OK	Widely used on structures. Generally supplemented by brushing or blast cleaning.
ally no icable.	Can be used prior to alkali cleaning or blasting.	Can be used prior to blasting.	Brief cycle widely used alone to roughen surface, or to remove particles embedded by blast cleaning.	Acid processes: see above. Alkali process OK with acidulated rinse.	See above. Sulfuric acid rinse used.	Widely used to produce roughened surface necessary for good adhesion. Often followed by brief pickling cycle.	Generally not used.	Usually not applicable.
ally no icable.	Can be used for heavy cleaning prior to alkali cleaning or electrocleaning.	Can sometimes be used prior to brief acid pickling cycle but often used prior to alkali cleaning or electrocleaning.	Brief cycle widely used to remove thin oxide films and sometimes to etch surface for improved bond.	Acid processes: see above. Alkali process OK.	See above.	Shot blasting not used because of matte surface produced. Very fine grit or wet blasting sometimes used, followed by light buff and chemical cleaning cycle.	Used for heavy cleaning smut removal and descaling prior to polishing.	Usually not applicable.
be used to blast ing.	Can be used prior to blast cleaning or chemical cleaning methods.	Can be used prior to blast cleaning.	Brief cycle can be used to remove particles embedded by blast cleaning. Sometimes used alone to roughen surface but bond not as good.	Acid processes: see above. Alkali process OK prior to blasting.	See above.	Widely used to produce roughened surface necessary for good adhesion. Often followed by brief pickling cycle.	Generally not used.	Widely used on structures, sometimes prior to blast cleaning.
lly no cable.	Can be used for heavy cleaning prior to alkali cleaning or electrocleaning, or prior to acid pickling.	Can be used prior to acid pickling.	Widely used. Dilute hydrochloric acid preferred as residual chlorides have fluxing action.	Acid processes: see above. Alkali process OK and desirable.	Widely used. Thorough rinsing and hydrochloric acid rinse needed.	Usually not applicable.	Scrubbing often used after pickling prior to hot dipping.	Usually not applicable.
No corro protec	Widely used. No corrosion protection.	Widely used. No corrosion protection.	OK with thorough rinsing and neutralizing.	Usually not needed.	OK	OK	Fine wire and treated fiber brushes widely used.	OK if supplemented by brushing, blasting or pickling.
	OK with clean solvent and thorough wiping. Can be used for heavy cleaning prior to alkali cleaning.	OK	OK	OK but used only where rapid removal of thick or tough scale desired.	OK	OK	Wire brushes widely used.	See above.
	OK provided sufficient time elapses for complete evaporation of solvent.	OK	Usually not applicable.	Usually not applicable.	Not applicable but often used for combined cleaning and heat treating.	Not applicable.	Not applicable.	Not applicable.
o corr protec	OK. No corrosion protection.	OK. No corrosion protection.	OK, when oxide or scale removal needed. No corrosion protection.	See acid pickling. Used only where rapid removal of thick or tough scale needed.	OK. No corrosion protection.	OK but longer tool life sometimes results if blast cleaning followed by acid pickling or salt bath cleaning to remove embedded particles.	OK	OK but usually must be followed by brushing to remove patches of scale that would be detrimental to tool life.

(Continued from page 123)

Within these limits it is necessary to select a shot small enough to permit a great many impacts per unit area per unit time, yet large enough to produce appreciable shock on impact.

There is also an important economic factor. Generally, the shots which are lowest in initial cost tend to be most expensive in the long run because they break down quickly and must be replaced. For this reason, cast iron shot is generally considered uneconomical. Cut wire shot is probably the most economical in the long run where ferrous metals are being cleaned and production rates are high. However, it is quite expensive, especially in small sizes, because of its method of production. Intermediate in both initial and long-run cost are malleable iron and steel shot and these are most widely used. Sand, the cheapest of all abrasives, is not nearly as effective as metallic shots and grits, and is used primarily where portable equipment is required and the abrasive is not recoverable, or on the softer metals for which ferrous shot and grit are not usually suitable. There are other cases where a cheap shot may be quite desirable. If the metal surface is greasy it would be advisable to use either an expendable nonmetallic grit or a shot that breaks down and is removed (with the grease) fairly rapidly, thus avoiding excessive buildup. Also, an inexpensive shot might be more economical if the design of the part is such that a significant quantity of shot is carried out in recesses.

Dry blasting is limited in the fineness of finish it can produce. For a fine finish comparable to that obtainable from wheel polishing, wet blasting must be used. Abrasives range in size from 60 to 2500 mesh and dimensions can be held as close as 0.0001 in. Wet blasting is also better adapted to complex shapes than is dry blasting.

A number of different types of machines are available. Where parts are fairly rugged and not too large, rotating barrels can be used to tumble the parts under the blast. Rotating or swing tables can be used for somewhat larger or more fragile parts, and "rooms" can be used for still larger parts. Generally wheel blast units are more economical than airblast units, but sometimes the flexibility of an airblast unit is needed to reach inaccessible surfaces or to clean parts too large for a machine. Wet blasting of small parts is generally handled in a special enclosed cabinet equipped for manual control of the operation.

Brushing

The most important variables in brush selection are the type of fill, fill density, flexibility and surface speed. Heavy cutting action is obtained with steel wire fills. More moderate cutting action is obtained with treated Tampico fiber loaded with abrasive, treated Tampico alone or untreated Tampico fills. Both faster cutting and finer finishes are obtained with higher density faces; these can be achieved by increasing the internal diameter of the brush. Flexibility varies chiefly with the trim length of the fill; the longer the trim length, the more flexible the brush; conversely, the shorter the trim length, the tougher the brush. Within the limits of safety, higher brush speeds increase the hardness of the brush face and give heavier cutting action. Wire sizes range from 0.005-0.050 in. and selection depends greatly on the surface finish desired, the finer wires giving finer surface texture. However, higher speeds with fine wires produce surfaces similar to those produced by larger wires at slower speeds. In fiber brushing with abrasive, of course, the finish is controlled by the size of abrasive selected.

Many standard brushes, such as wheel, cup and end brushes, are available in a standard range of sizes. Special shaped brushes are manufactured to specifications for particular applications. Although even power brushing is often considered a "manual" operation because of the necessity of positioning and holding parts against the brush, the operation can be largely mechanized where production rates justify the expense of special equipment.

Tumbling

Selection of the grinding chips and cleaning compounds for barrel cleaning or tumbling depends to a great extent on the primary purpose of the operation. For light deburring, accompanied by cleaning, alkali cleaning compounds would be used. Where heavy deburring or scale removal is the principal aim, an abrasive compound would be used. For ordinary cleaning and descaling, fairly inexpensive quartz chips might be used. Where heavy deburring or descaling is required, shorter cycles can be obtained by use of more expensive aluminum oxide chips which have faster cutting action.

Tumbling machines are available in many different types. Most consist of a barrel rotating on a tilted or horizontal axis. In some, provision is made for fixing the parts in position, and one fairly new design allows the fixed parts to rotate counter to the barrel rotation. Selection of the most economical barrel depends on the size and quantity of the parts and the time cycle required.

Rinsing

Rinsing serves one or both of two purposes: it removes the cleaner and any attached contaminations; it may also neutralize or condition the surface. Ordinary water rinses may be dip or spray and hot or cold. A spray rinse brings a continuous stream of clean water in contact with the metal surface but it is, of course, more expensive than dipping. Sometimes a combination of dip and spray can be used, with the spray insuring final contact with clean water. Hot water is more effective than cold, and dip rinses are usually hot. The much greater volume of water required makes cold water considerably less expensive in spray rinsing, but an emulsion cleaner usually requires a hot spray rinse for adequate removal. Another factor involved in the choice between hot and cold rinses is the subsequent fabricating operation. A cold rinse is often preferred where the next operation is also wet or where it is desirable to keep the metal surface protected from the atmosphere prior to the next operation. A hot rinse is often preferred where a dry surface is required and there is no danger of undue oxidation. However, there are special compounds on the market that make it possible to air-dry ferrous parts after rinsing without any rusting. These water-soluble inorganic compounds are added to the rinse water and are claimed to provide protection not only during the drying operation but for a considerable period of time thereafter.

Where residual alkali must be counteracted, the rinse may contain dilute acid, such as phosphoric or sometimes chromic, or a separate neutralizing dip can be used. In some cases the purpose is not only to remove potentially harmful alkali but also to promote a definite surface condition, less susceptible to oxidation and more compatible with subsequent finishing operations. Similarly, sodium cyanide or other alkali salt can be used to neutralize the surface following acid pickling.

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Enthone, Inc.
Hanson-Van Winkle-Munning Co.
Hooker Electrochemical Co.
E. F. Houghton & Co.
Kolene Corp.
MacDermid, Inc.
Neilson Chemical Co.
New Jersey Zinc Co.
Northwest Chemical Co.
Norton Co.
Oakite Products, Inc.
Osborn Mfg. Co.
Pangborn Corp.
Pennsylvania Salt Mfg. Co.
Roto-Finish Co.
Tumb-L-Matic, Inc.
Vapor Engineering Corp.

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Materials Data Sheet

Malleable Irons

Malleable iron is an alloy consisting largely of an iron matrix containing dispersed nodules of graphite. Pearlitic malleable irons are similar to standard malleable in composition but the carbon is present in different forms with the result that strength is increased but ductility is reduced. Malleable iron differs from gray cast iron in the manner of distribution of the graphite and because of this difference the properties of the two materials are quite different.

TYPE AND GRADE	Standard 32510	Standard 35018	Pearlitic
COMPOSITION, %	C 2.3/2.7 Si 1.5/0.8 Mn 0.55 max P 0.18 max S 0.20 max	C 2.0/2.45 Si 1.4/0.85 Mn 0.55 max P 0.18 max S 0.20 max	Same as standard grades except that Mn can be higher.
PHYSICAL PROPERTIES			
Density, Lb/Cu In.	0.259–0.263	0.259–0.263	0.259–0.263
Thermal Cond, Btu/Hr/Sq Ft/Ft/F			
@ 80 F	29.5	29.5	[1]
@ 700 F	23.0	23.0	[1]
Coeff of Exp per F, 68 to 750 F	6.6×10^{-6}	6.6×10^{-6}	[1]
Mean Spec Ht, Btu/Lb/F (70 to 750 F)	0.133	0.133	—
Elect Res, Microhm-Cm @ 68 F	32.0	32.0	38.19 to 41.17
Spec Volume, Cu Cm/Gm @ 68 F	0.1366	0.1366	0.1366
Shrinkage Allowance (Contraction Minus Expansion During Anneal)	11/64–1/32	11/64–1/32	11/64–1/32
Magnetic Properties	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES			
Mod of Elasticity in Tension, Psi	25×10^5	25×10^5	28×10^5
Tensile Str, 1000 Psi	50–52	53–60	60–90
Yield Str, 1000 Psi	32–35	35–40	40–70
Elong in 2 In., %	10–18	18–25	12–3
Red of Area, %	18–23	18–23	—
Hardness, Bhn	110–145	110–145	160–285
Impact Str, Charpy, Ft-lb (V-Notch 0.079 In. Deep, 0.394 = In. Sq Bar)	16.5	16.5	12
Fatigue Str (End Limit), 1000 Psi	25	31	30–32
Endurance Ratio	0.50	0.50	—
Modulus of Elast in Compression	25×10^5	25×10^5	—
Compressive Yield Str, 1000 Psi:			
1% Perm. Set:	28	28	43
At Failure:	90+	90+	—
Ult Shear Str, 1000 Psi	45–48	48–54	—
Yield Str in Shear, 1000 Psi	29–32	32–36	—
Mod of Rupture in Torsion, Psi	58,000	58,000	—
Poissons Ratio	0.17	0.17	—
Allowable Working Stress at 775 F, Psi	5603	5600	—
THERMAL TREATMENT			
Hardening Temp, F	1500[2]	1500[2]	1500
Tempering Temp, F	—	—	About 600
FABRICATING PROPERTIES			
Casting Temp, Range, F	2600–2800	2600–2850	2600–2850
Machinability Index (B1112 Steel = 100)	120	120	80–90
Weldability	Not fusion welded. Can be soldered and brazed.		
CORROSION RESISTANCE	Resistant to atmospheric corrosion in rural, industrial and marine atmospheres; fresh and salt waters.		
USES	Gear cases, brake supports, journal boxes, pipe fittings, pole line hardware, ordnance parts, marine deck fittings, anchors, parts for domestic appliances and business machines.		Rocker arms, camshafts, gears, sprockets, tractor parts, agricultural machinery parts.

NOTES: [1] *Estimated to be somewhat higher than standard grades.*
[2] *Must be first heated to 1700 F to dissolve graphitic carbon.*

◂ For more information, Circle No. 498

Which Carburizing Grade of Tubing Is Best for You?

...B&W Can Supply Them All

When you want to carburize for hard surface and at the same time maintain a tough core, it is wise to examine all available carburizing grades to determine which is most suitable for your specific operation. The low-carbon alloy steels listed are typical of those designed for ease of carburization.

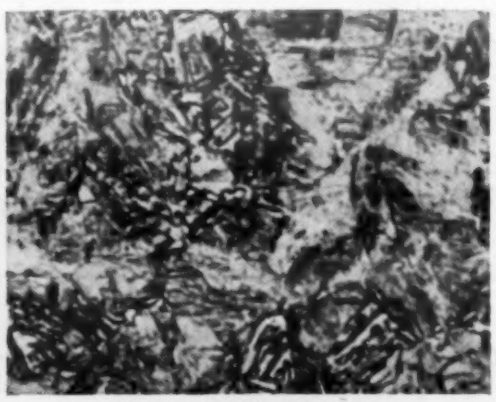
After carburizing, the steel has a high carbon content on the surface and only the carbon content of the base alloy in the core. This provides, after suitable heat treatment, a surface which is hard and wear resistant and a core that is tough and ductile—a combination desired in many applications. Alloying elements impart an ability to develop a deeper case for a given set of carburizing conditions and provide a more gradual transition in microstructure and hardness from case to core than in a plain carbon steel.

In the application of these low-carbon alloy steels it is possible, in many instances, to use alternate grades without loss of desirable mechanical properties. Discuss your requirements with Mr. Tubes—your nearby B&W Tube Representative. You'll find B&W Bulletin TDC-149 helpful, too. Write for it.

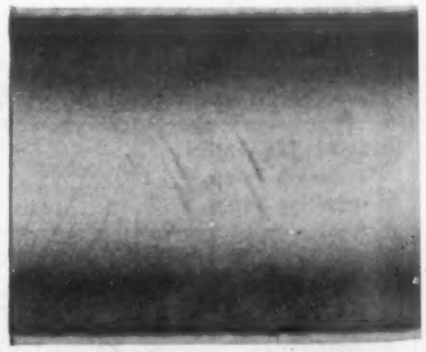
TYPICAL GRADES

1320
2317
2515
3120
E3310
4023
4320
4620
4815
5120
6120
8620
8720
E9310

Micro at 1000X of the case



Micro at 1000X of the core



Macro of the tube wall at 5X

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-1746 (C)

For more information, turn to Reader Service Card, Circle No. 305

Materials Engineering File Facts

MATERIALS & METHODS
November • 1953
Number 264

Materials Data Sheet

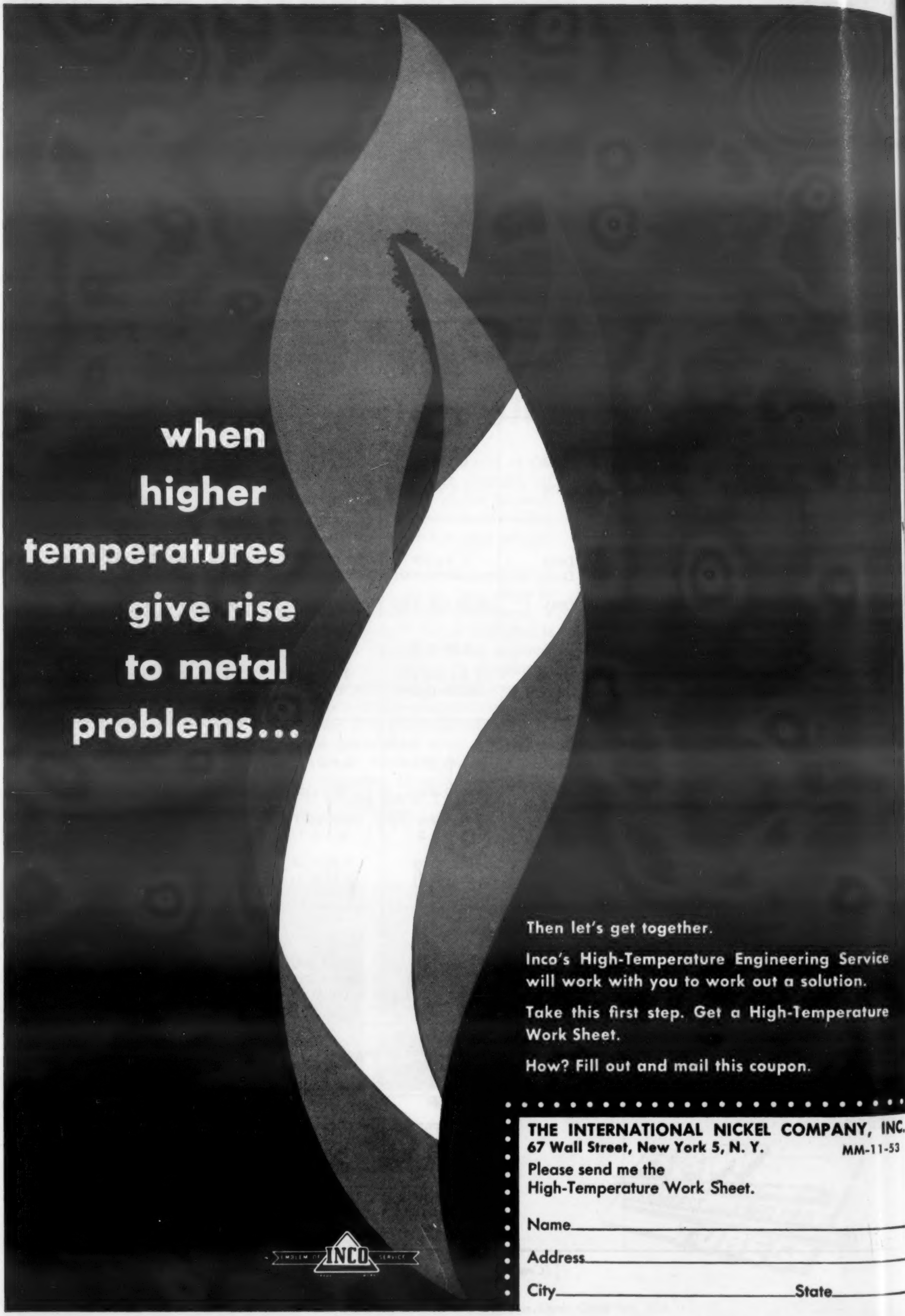
Melamine-Formaldehyde Molded Plastics

These are thermo-setting materials which are usually compression molded but are often transfer molded. Various types of filler are incorporated in the resin to modify the properties. These plastics are hard and rigid, insensitive to heat and flame resistant.

Recommended maximum service temperatures range from 210 to 300 F depending on the filler.

TYPE (Corresponding to ASTM Spec. D704-51T)	ASTM Test Condition	Alpha Cellulose General Purpose Type 1	Mineral Filled Electrical Type 2	Low to Intermediate Shock Resistant Fabric Filled Type 3	Intermediate Resistance Fabric Filled Type 4
PHYSICAL PROPERTIES					
Spec Gravity	D792	1.47–1.52	1.78	1.5	1.5
Thermal Cond, Btu/Hr/Sq Ft/Ft/F, @ 212 F	—	2.47	3.92	3.08	2.93
Coeff of Exp per F:	D696	2.2×10^{-5}	1.8×10^{-5}	1.5×10^{-5}	1.5×10^{-5}
MECHANICAL PROPERTIES					
Mod of Elast in Tension, Psi	D638	1.3×10^{6}	1.95×10^{6}	1.6×10^{6}	1.6×10^{6}
Tensile Str, Psi	D638	5,000–13,000	5,500–6,500	8,000–10,500	5,700–9,000
Hardness, Rockwell	D785	M118–124, E110	E90	M119, E100	M114, E93
Impact Str, Izod Notched (Ft-Lb per in. of Notch)	D256	0.24–0.35	0.3–0.4	0.5–0.9	1.0–1.5
Mod of Elast in Flexure, Psi	D790	$1.3–1.6 \times 10^{6}$	1.6×10^{6}	1.8×10^{6}	1.9×10^{6}
Flexural Str, Psi	D790	10,000–17,000	8,700–10,000	12,000–15,000	13,000–17,000
ELECTRICAL PROPERTIES					
Elect Res, Ohm-Cm @ 68 F	D257	10^{12}–10^{14}	0.6×10^{12}	10^{9}–10^{10}	—
Dielectric Str (Short Time) Volts/Mil	D149	300–400	410–430	310–350	130–370
Dielectric Constant: 60 cycles	D150	7.9–9.5	7.2–10.3	7.6–8.6	10.5–15.5
1,000,000 cycles	D150	7.2–8.2	6.4–6.7	6.5–6.9	6.1–6.7
Loss Factor: 60 cycles	—	0.22–0.78	0.62–1.49	0.53–0.97	3.3–5.0
1,000,000 cycles	—	0.21–0.31	0.23–0.30	0.23–0.24	0.30–0.42
FABRICATING PROPERTIES					
Compression Ratio (Bulk Factor)	D392	2.1–3.0	2.4	10–5([a])	10–5([a])
Compression Molding Temp F	—	280–370	275–340([b])	275–330([c])	320–380([c])
Compression Molding Pressure, Psi	—	1,500–8,000	1,000–6,000([b])	4,000–8,000	4,000–8,000
Mold Shrinkage in./in.	—	0.006–0.015	0.005–0.007	0.003–0.004	0.004–0.005
CORROSION RESISTANCE	Resistant to weak acids, weak alkalies, organic solvents, greases and oils; attacked by strong acids and strong alkalies.				
USES		General purpose electrical and mechanical applications such as kitchenware, tableware, lighting fixtures, reflectors.	Elevated temperature and electrical applications such as ignition parts, circuit breakers, terminal blocks, electronic parts.	Improved impact strength for insulation, circuit breakers, food trays, medical equipment.	Medium impact strength for nozzles, insulation.

(Continued on page 141)



For more information, turn to Reader Service Card, Circle No. 322

Materials Engineering File Facts

MATERIALS & METHODS
November • 1953
Number 264

Melamine-Formaldehyde Molded Plastics (Continued)

TYPE (Corresponding to ASTM Spec. D704-51T)	ASTM Test Condition	Unfilled Type 5	Cellulose Filled Electrical Type 6	Cellulose Filled Electrical Type 7
PHYSICAL PROPERTIES				
Spec Gravity	D792	1.48	1.45	1.43
Thermal Cond, Btu/Hr/Sq Ft/Ft/F, @ 212 F	—	—	2.42	—
Coeff of Exp per F:	D696	—	$1.80–2.75 \times 10^{-5}$	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, Psi	D638	—	1.1×10^6	—
Tensile Str, Psi	D638	—	5,700–6,500	5,500–6,500
Hardness, Rockwell	D785	—	E94, M116-124	—
Impact Str, Izod Notched (Ft-Lb per in. of Notch)	D256	—	0.26–0.38	0.38–0.41
Mod of Elast in Flexure, Psi	D790	1.3×10^6	1.3×10^6	—
Flexural Str, Psi	D790	11,000–14,000	8,000–10,000	9,000–10,000
ELECTRICAL PROPERTIES				
Elect Res, Ohm-Cm @ 68 F	D149	—	—	—
Dielectric Str (Short Time) Volts/Mil	—	—	360	380
Dielectric Constant: 60 cycles	D150	—	7.0–8.4	13.0
1,000,000 cycles	D150	—	4.7–6.7	6.2
Loss Factor: 60 cycles	—	—	0.105–0.92	3.9
1,000,000 cycles	—	—	0.145–0.40	0.25
FABRICATING PROPERTIES				
Compression Ratio (Bulk Factor)	D392	2.0	2.4	2.7
Compression Molding Temp F	—	300–330	300–350(d)	300–350(d)
Compression Molding Pressure, Psi	—	2,000–5,000	1,500–6,000	1,500–6,000
Mold Shrinkage in./in.	—	0.011–0.012	0.007–0.008	0.006–0.007
CORROSION RESISTANCE	Resistant to weak acids, weak alkalies, organic solvents, greases, and oils; attacked by strong acids and strong alkalies.			
USES		Pearlescent buttons, moldings, ornamental applications.	General mechanical and electrical applications particularly at elevated temperatures such as electrical and electronic parts.	Improved holding power for metallic inserts uses include electrical and electronic parts.

NOTES:
(a) *Loose and packed respectively.*
(b) *Transfer molds readily at 275–340 F, 1000–6000 Psi.*
(c) *Limited transfer molding possibilities.*
(d) *Can be transfer molded readily at 300 to 350 F, 6,000 to 20,000 Psi.*

Prepared with the Assistance of the Manufacturing Chemists' Association, Inc.
Based on the Chemists' Association publication "Technical Data on Plastics," 1952

For a lead "pan" cinch...

it's THERMALLOY* to outlast cast iron by 479 days!

A large steel and wire company uses a double-lead patenting furnace to give good drawing qualities to wire. In this process, wire is drawn through a "lead" pan enclosed in the furnace where temperatures range from 1600 to 1650°F.

Previously, cast iron "lead" pans were used . . . and the furnace had to shut down nearly every 21 days because the pan burned out and needed replacement. Then, a Thermalloy "lead" pan with integrally cast sinkers was installed. *To date, this pan has over 500 days of service* . . . saving this company expensive hours of repair and down time.

This is just one example of how a Thermalloy heat-resistant casting has helped a manufacturer to realize more economy in heat-treating parts. Do you have a similar need for Thermalloy in retorts, furnace parts, trays, racks, pots or muffles? Call in an Electro-Alloys engineer for full information, or write Electro-Alloys Division, 4001 Taylor Street, Elyria, Ohio.

THERMALLOY "LEAD" PAN ADVANTAGES

- Resists air-line attack, scaling and oxidation.
- Higher strength prevents sagging and distortion.
- Less weight means easier installation and less maintenance of supporting arches.
- Greater resistance to abrasion.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

For more information, turn to Reader Service Card, Circle No. 410

New Materials and Equipment

New Material May Become Base for Another Family of Plastics

A new material, vinyltoluene, closely related to styrene, is now in developmental stages and is available from pilot plant production at the *Dow Chemical Co.*, Midland, Mich. Designated Experimental Monomer X-783, the monomer is a liquid, slightly lighter than styrene, but with a higher boiling point, a higher flash point, and much lower freezing point.

Such developmental work as has been done with vinyltoluene indicates that it may be used for modifying oils, alkyd resins, and laminating resins in much the same way as monomeric styrene, but with the advantage of producing materials soluble in lower-cost solvents. In general, the copolymers produced with vinyltoluene and these materials possess a wider compatibility than those produced with styrene. Copolymers are formed with all conventional drying oils and oil-modified alkyds to form clear, compatible vehicles.

The typical properties of the technical grade of the monomer are as follows:

Specific gravity	0.89
Weight, Lb per Gal	7.4
Boiling Point, @ 760 mm	338-340 F
Flash Point	140 F
Freezing Point	—116.5 F
Viscosity, @ 77 F	0.770 cps

Experimental work has shown that the new material has possibilities for use as a copolymer in the production of synthetic rubbers, and more immediately, it holds out the possibility of use as a rubber fortifying ingredient. It also shows promise of finding a field for itself as an ingredient in paint vehicles and potting resins.

Vinyltoluene is polymerized with oils to form chemically resistant paint vehicle.

New Non-Metallic Permanent Magnet Material

The need for critical metals such as nickel, cobalt, tungsten, or chromium is eliminated in a new permanent magnet material, made by a powder metallurgy process from a mixture of barium and iron oxide. Said to be the first ceramic permanent magnet material to be made in this country, Magnadur was developed by *Ferroxcube Corp. of America*, Saugerties, N. Y. The company says that the initial production of the material for the balance of this year will be concentrated on toroidal rings for TV focusing ring magnets.

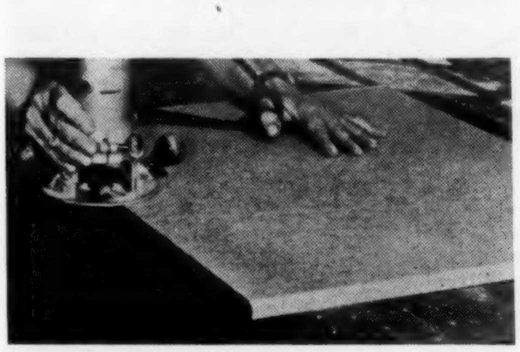
The manufacturer says that Magnadur has extremely high coercive force and unusually high resistance to demagnetization as well as excellent magnetic stability. Its high resistance permits its use in the presence of high frequency fields without undesirable losses.

New Hardboard Panels Are Warp-Resistant

A new hardboard panel, in thicknesses up to ¾ in. has been made available by *Forest Fiber Products Co.*, Forest Grove, Ore. Made of pressed Douglas Fir fibers, Forall is said to be warp-resistant and smooth on both sides. Since it is grain free, the manufacturers say it can be sawed, rabbeted or routed without splintering or splitting. No patching is needed on the edges, nor is an edge trim necessary to finish.

The company states that the screw and nail holding strength of Forall compares favorably with other materials and the surface will take stains, waxes, paints and enamels.

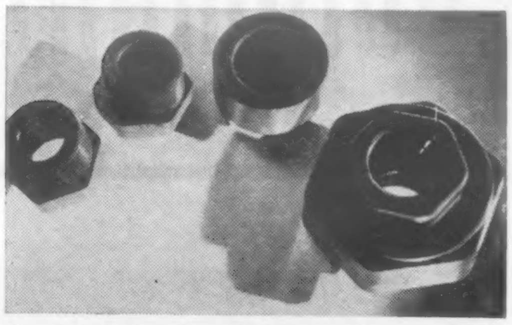
Forall is available in thicknesses of ⅜, ½, ⅝, and ¾ in.



Grain-free, Forall can be worked without splintering of edges.

New Materials and Equipment continued

Corrosion Resistant Fittings for Plastic Pipe



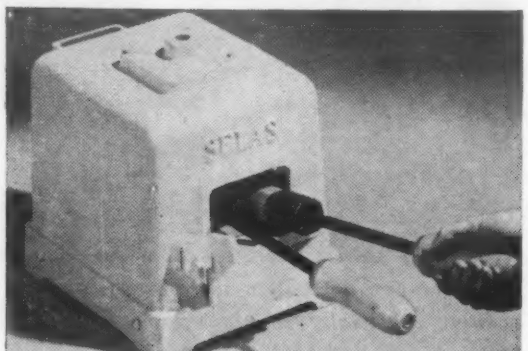
Plastic fittings make possible complete plastic pipe systems.

Reducing bushings, plugs, unions and caps made of unplasticized polyvinyl chloride have been added to the line of fittings to be used in conjunction with Boltaron pipes and valves made of the same material. These new fittings are distributed by *H. N. Hartwell & Son, Inc.*, Boston, and they make possible a complete, continuous system of plastic piping for a variety of industrial corrosion resistance applications.

The manufacturer states that the Boltaron 6200 material has shown resistance to organic and inorganic acids, alkalies, alcohol and foodstuffs, making it particularly applicable for use in industries such as the textile, beverage, tanning, plating, dyeing, chemical and petroleum.

The new fittings are now available in quantity in standard I.P.S. sizes.

Soldering Furnace Uses Radiant Burner as Heat Source



Heat transfer rates are high in radiant heat soldering furnace.

A new gas-fired soldering furnace, using a radiant burner as a heat source, is said to be capable of heating in less than 8 min, two 4 lb irons from room temperature to 900 F, or one 4 lb iron to 1200 F, with a heat input of only 9100 Btu per hour.

Designed by *Selas Corp. of America*, Erie Ave. & D St., Philadelphia, the unit features a burner so located as to minimize mechanical shock and flux corrosion damage. The refractory hearth is said to be easily removable for cleaning, and the die-pressed furnace lining is quickly installed in case of replacement.

The heating is accomplished without flame impingement, yet the soldering copper is surrounded by fully-burned gases which are said to almost eliminate oxidation and burning of the copper. The lower heat input is possible because of higher heat transfer rates in radiant heat. The lowered input, plus the use of good insulating lining, is said to prevent high temperatures in the furnace casing, and a tilted shelf limits the escape of much of the excess heat which, instead, is carried off through a flue.

Two New Enamels: A Water-Reducible and a Modified Silicone

Two new enamel coatings have been developed by the *General Industrial Div. of The Sherwin-Williams Co.*, one utilizing the water emulsion process, the other using a method of harnessing inorganic to organic materials to provide a heat-resistant, non-yellowing enamel.

Water Reducible—One of the first successful adaptations of the water emulsion process in the field of industrial coatings is claimed by the company for their water-reducible enamel. Only the addition of water is necessary to achieve the desired viscosity for application. The emulsion in the liquid form is non-flammable at normal room or operating temperatures, though after application and drying it does become combustible to a limited degree. It is not water-soluble after application and its oil resistance is said to be very good.

In addition to the economic advantages inherent in the use of water as a reducing agent, the coating is said to be very hard with high impact resistance and adhesion properties. Its qualities meet the requirements of the automotive, electrical, and other metalworking industries. At present, the finish is produced only in black but the company says that it can be made in a range of colors. It is adaptable to either dip or spray methods of application and is said to provide a high gloss finish. The enamel should be air-dried for 20 min, then baked for approximately 18 min at about 300 F.

Modified Silicone—Kemclad Hi-Heat Enamel is a modification of the silicone class of materials, designed as a non-yellowing enamel for coating household appliances and other equipment exposed to sustained, moderately high temperatures. It is said to have high impact resistance minimizing the chipping problem, and will retain a glossy, non-yellowing finish under sustained temperatures up to 500 F.

The use of both inorganic and organic materials in the finish is said to have reduced the price of the enamel to approximately half that of present silicone finishes. It has good adhesion qualities and has been successfully subjected to tests with salt spray, hot grease, humidity, chemicals and household cleansers.

At the present time the finish is offered in white only, formulated for spray application. It is reduced 20% with xylol or toluol and requires a 30 min baking period at 400 F.

Leaded Alloy Steel Provides Faster, Cooler Cutting

A new alloy steel, leaded AISI 4140, is said to machine up to 50% faster than standard medium carbon alloy steels, provide cooler cutting, and increase the life of the cutting tool up to 100%. Now available from warehouse stocks at *Joseph T. Ryerson & Son, Inc.*, Box 8000-A, Chicago, the new alloy retains all of its original heat-treat characteristics or hardenability, and the mechanical properties developed through heat treatment are identical to those developed in AISI 4140 without lead.

In the annealed condition, it is possible for leaded AISI 4140 to be machined at the same feeds and speeds as recommended for C-1117 which has a machinability rating with about 15% of B-1112 screw stock. The company states that the new alloy, heat-treated, also machines 50% faster than the standard AISI 4140 heat-treated.

Cold finished bars of leaded AISI 4140 are available from Ryerson in both the annealed and heat-treated conditions, in sizes from 1/4 to 3 in., in 10 to 12 ft lengths.

Leaded AISI 8620, a low carbon, carburizing alloy, offering the same improvement in machinability as leaded AISI 4140 and which may be heat treated in the same manner, has also been made available by Ryerson.

Ductile Iron Bar Stock Now Available

Cast iron bar stock has been available for some time from iron foundries; however, the production of ductile iron bar stock has posed a problem due to the difficulty in overcoming center-line shrinkage. The *Howard Foundry Co.*, 1700 N. Kostner Ave., Chicago, claims to have solved this problem and is producing the material, sound from end to end and able to pass x-ray inspection for density, the company states.

The as-cast average properties of these ductile iron bars are 100,000 psi tensile strength, 65,000 psi yield, 3½ to 4½% elongation and a Brinell hardness of 245. The bars can be heat treated for greater elongation and hardness.

Ductile iron machines very well and has excellent anti-friction qualities since the graphite is still in matrix after inoculation of magnesium. It can be used in production or specialty work in such applications as pins, bushings, shafts, bearings, seals, valve guides and others.

Heat Treat and Quench Unit Features Automatic Control

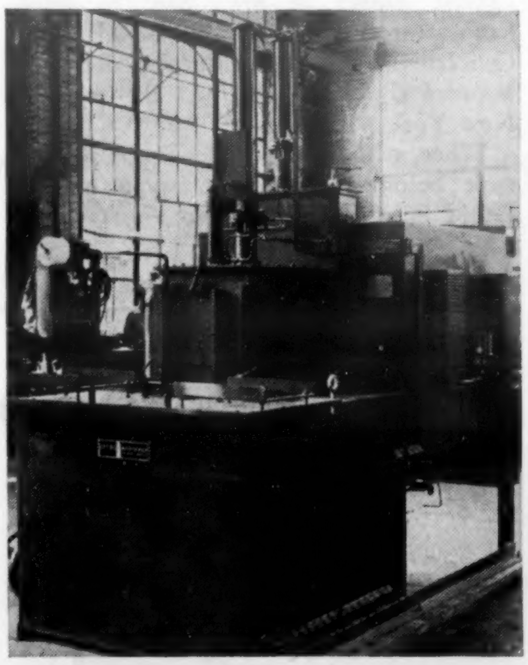
A forced-convection furnace which provides automatic control of temperature and atmosphere throughout both the heating and quenching cycles has been developed by *Leeds & Northrup Co.*, 4908 Stenton Ave., Philadelphia. The new unit, made up of three components—a horizontal Homocarb furnace, Microcarb Atmosphere Control, and L&N Temperature control—provides protected quench so that the load is never exposed to air from the time it enters until it is unloaded, and is kept under regulated conditions.

The furnace itself combines in one unit a heating chamber, a quench tank, and a protective-atmosphere vestibule. The Homo principle of forced convection is used to maintain uniform circulation in both the heating chamber and quench. In the heating chamber a high pressure fan circulates heat and atmosphere uniformly throughout the load. In the quench a large motor-driven pump circulates oil down through the load. Between heating and quenching, the work is protected in a sealed vestibule under the controlled atmosphere generated in the heating chamber.

The Microcarb Atmosphere Control measures and controls the carbon content of the atmosphere surrounding the work during the heat-treating cycle. The detecting element is located in the work chamber and detects the active carbon in the atmosphere. The recorder draws a continuous record of per cent carbon, while the controller balances carbon content of the atmosphere against the setting of a control dial, increasing or decreasing the flow of Homocarb fluid to the furnace to maintain the desired atmosphere.

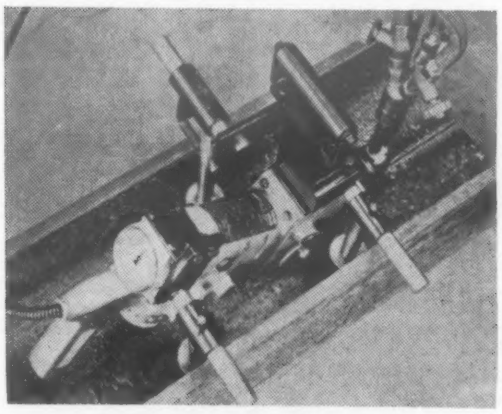
Temperature in the heating chamber is controlled by a D.A.T. three-function control system, while an Electromax on-off controller regulates temperature of the quench oil by operating a heat exchanger or immersion heater.

The equipment can be used between temperature of 1500 to 1750 F and throughout a carbon range of 0.15% to 1.15% C.



The load is protected from air throughout heat treat and quench cycle in the automatic furnace.

New Materials and Equipment continued



Straight cuts are assured by three guide rollers traveling on flanges of I-beam.

Automatically Guided Tool Aids in Cutting Metal Shapes

The *American Pullmax Co., Inc.*, 2455 N. Sheffield Ave., Chicago, has marketed a new model HP Cadet flame cutting machine which, guided by three laterally adjustable rollers, makes straight longitudinal cuts on I-beams and wide flange beams from 5½ up to 11¾ in. The Model HP can also be used for making straight cuts or cutting limited irregular shapes from plates.

The tool is automatically guided by means of two fixed rollers running along a 1½ to 2½ in. steel strip or angle iron previously fastened to the plate. The speed of travel and gas flow to the torch are controlled by adjustments on the handle.

Cadet flame cutting machines are adaptable for use with acetylene, propane or hydrogen gases. The weight of the entire machine including guide rollers is 29 lbs.

Thin Gage Tantalum Strip Now Available

Tantalum, an extremely non-magnetic and corrosion resistant metal, with tensile properties comparable to cold-rolled steel, is now available in strips up to 6 in. wide and down to 0.0005 in. thick, with tolerances held as close as ±0.0001 in., from the *Industrial Div., American Silver Co., Inc.*, 36-07 Prince St., Flushing, N. Y. The company says the strip is commercially available in any quantities.

Typical uses for the strip include: high precision instrument condensers, amplifiers, oscillators in the electronics industry, acid-proof equipment, apparatus for chlorination of water, coolers and condensers in the chemical processing industry, thermometer wells, timing devices, and signal and alarm systems.

Insulating Concrete Protects Gas Tanks from Fire

A light-weight insulating concrete consisting of a kaolin base and a hydraulic setting cement binder is now available to protect propane and butane storage tanks against danger of fire. Said to resist temperatures to 2000 F, B&W K-20 Concrete Mix has been developed by the *Babcock & Wilcox Co.*, 161 E. 42nd St., New York.

When a liquefied petroleum gas storage tank becomes overheated, some of the liquid in it is converted to a gas which builds up an abnormal pressure. At the same time, the hotter the steel tank shell becomes, the less strength it has to withstand extra pressure from within. As a result it may rupture, explode and rocket, releasing the pressurized gas to ignite.

This new fire-proofing material is applied with a cement gun to a thickness of 1½ in. on the outside of the tank, and is supported by steel car banding straps fastened against the tank casing by band tighteners. To these straps are fastened bent clips which, in turn, anchor the K-20 Concrete Mix and serve as a spacer for a 2 in. galvanized steel wire mesh reinforcement. Prior to application of the cement, the tank shell is covered with a corrosion resistant paint to protect the metal from water vapor which may condense on the outer surface of the tank. After the concrete has thoroughly dried, the outer layer of the insulation is sprayed with a weatherproof coating of a type which provides a good water-vapor seal.

Two New Self-Molding Packing Compounds

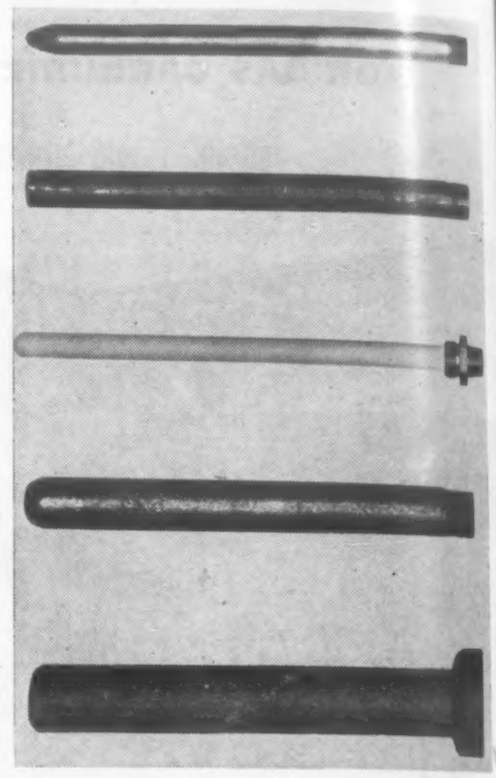
Surveys, Inc., 219 Euclid Ave., Trenton, N. J., has marketed two new self-molding compounds which will withstand high temperatures in valves, pumps and expansion joints.

The first, "Copperstícks" is made up of a dispersion of pure copper flakes throughout the body of the stick shaped compound. Soft, yet form-stable, it is said to meet requirements for the average industrial process plant. It is designed expressly for steam, hot water, or process air applications under vacuum or pressure. The density of the compound is said to prevent oxygen corrosion of pipe lines.

"Molyvac", developed for valves and pumps operating under negative pressures is said to be the densest compound developed for such purposes. The manufacturer states that it will positively maintain sustained sealing efficiency at temperatures ranging from —30 to 500 F, while special formulations are available for temperatures ranging from —20 to —100 F. The compound will not harden in extended use and the company states that it has found wide application in reactor agitator stuffing boxes, refrigerator systems, and so forth.

(*Continued on page 148*)

New Materials and Equipment



Thermocouple Protection Tube Provides Close Control

A new tube, said to provide closer temperature control at reduced cost, has been added to the line of pyrometer supplies offered by *Arklay S. Richards Co., Inc.*, Winchester St., Newton Highlands, Mass. The tube is of extra heavy drawn construction with ½ in. pipe thread and has over 25% more metal than standard weight tubes. The use of Incoloy—32% nickel, 21% chromium—is said to increase the life of the tubes.

A close fit around a No. 8 gage thermocouple keeps air space and mass of the tube to a minimum and is said to provide closer control. Tubes are available in stock in multiples of 6 in. and the same alloy is also stocked in ¾ and 1 in. pipe sizes.

Non-Shrink Epoxy Resins for Tooling Applications

Two new non-shrink laminating resins are now available for such applications as fabrication of jigs and fixtures, models, prototypes, molds, and tool masters. Developed by *Rezolin, Inc.*, 5736 W. 96th St., Los Angeles, they are modified epoxy resins with 100% solids content and the manufacturer states that they will not settle. Company tests indicate that the resins are not corrosive or brittle and need no special facilities for handling.

Toolplastik L-900 is designed for use in standard laminating applications, while

New Materials and Equipment

Toolplastik Gelkote L-910 is said to produce a high gloss surface. The company says that both may be used in the same tool to produce glossy surface finishes that do not require polishing or machining. Gelkote L-910 is used to form the surface layer and is backed up by reinforcing glass fabric and L-900 to the required thickness.

Metal-Wood Lamination Provides New Material

A new material for the metalworking industries, consisting of a 1/10 in. basswood core, faced on both sides with aluminum or stainless steel to comprise an overall thickness of ⅛ in., is said to allow fabricators to use less metal since lighter gages can be utilized.

The material, Forming Grade Armorply, produced by *U. S. Plywood Corp.*, 55 W. 44 St., New York, makes use of the plywood or core material to supply the column strength and stiffness to the thin metal skin. The company says that it can be processed with standard metal working equipment, and has good forming, bending, cutting, and punching properties.

Two Welding Materials: Hard Overlay and Root Protection Flux

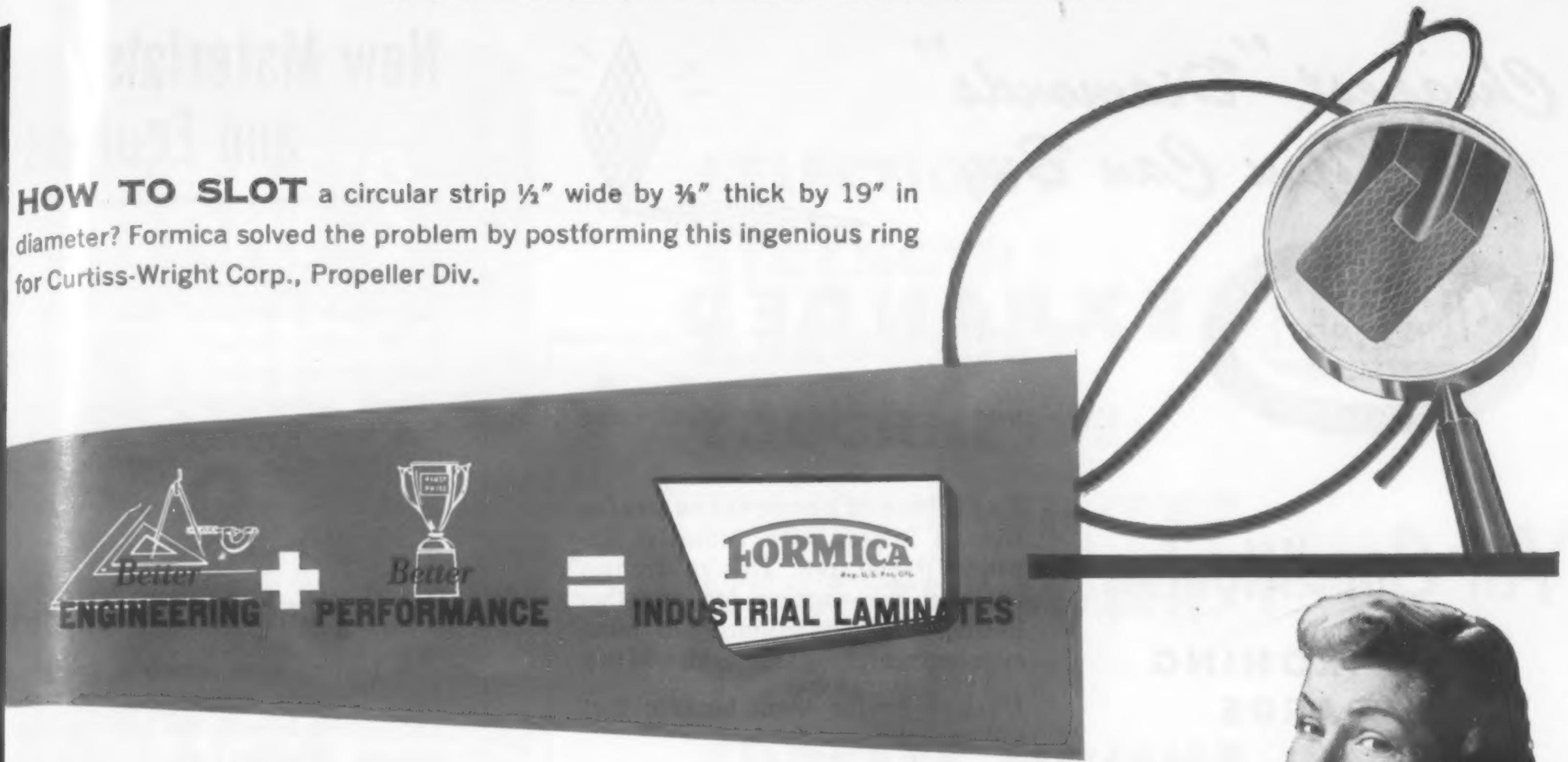
Eutectic Welding Alloys Corp., 40-40 172 St., Flushing, N. Y., is now marketing a hard overlay which can be applied with almost "skin thickness", and a stainless steel flux designed to protect the root of an inert gas joint.

Eutec-Instant-Overlay (KR 6900), available in both powder and paste form, can be painted on the metal surface, and after melting by torch or carbon arc, bonds to the metal to form an overlay up to 65 Rockwell C hardness, the company says. Successive applications can be used to create a thicker film for increased wear resistance. It is said to have many applications in the field of maintenance and preventive maintenance, such as elevator steps, ramps, fork trucks and similar farm and industrial applications.

Eutector Flux 569-I is designed to serve as a back-up flux for stainless steels and nickel, monel, Inconel and other alloys. When applied to the underside of butt and corner joints, penetration is said to be simplified by the flux action in controlling the molten weld metal, assuring

For more information, turn to Reader Service Card, Circle No. 306

HOW TO SLOT a circular strip ½" wide by ⅜" thick by 19" in diameter? Formica solved the problem by postforming this ingenious ring for Curtiss-Wright Corp., Propeller Div.



MINIATURIZATION is but one advantage of Formica printed circuits. Engineering developed better adhesives, postforming, molding and fabricating of complete circuit parts.

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New Materials and Equipment

underbead protection. The flux is said to be easily removed, making it particularly advantageous for use in aircraft exhaust systems, for welding seams in high finish stainless steel equipment, and for a variety of similar inert gas welding applications.

Bearing Alloy for Overlay Work

A bearing alloy which is said to supplant the wear properties of phos-bronze and bearing bronzes has been marketed by *Eutectic Welding Alloys Corp.*, 40-40 172 St., Flushing, N. Y. The manufacturer states that the structure of the deposit obtained with the rod, after heat treatment, shows wear resistance greater than that of conventional bronze welding rods or electrodes.

"Frix" is said to be a soft mass with embedded crystals of a wear-resistant copper alloy which combines both impact resistance and hardness. The deposits also possess elasticity and lubricating properties provided by the lower melting alloys included in the formulation.

Instead of the present method of using inserts machined out of phos-bronze stock, machined separately, then attached, "Frix" is said to permit the use of a film-like deposit which can be heated for maximum properties resulting in integrated bearings. The manufacturer predicts its use in machines, pumps, railroad equipment, rolling mills, and similar operations where bronze bearing problems exist.

Hardfacing Electrode for Build-up and Repair

The use of 1% molybdenum rather than 3.5 to 4.9% nickel is said to preserve the toughness as well as raise the yield strength of deposits made with the new V-Mang rod developed by *American Manganese Steel Div.*, Chicago Heights, Ill.

Austenitic manganese steel is ductile and tough at red-heat temperature, but when it cools slowly, as the deposit cools from a welding temperature, it becomes hard and brittle unless a "preservative" is added. Until recently, nickel was thought to be the best metal for this purpose, since it maintained the toughness of the deposit; however, the nickel could not raise the yield strength which is an important factor in impact resistance.

The Amsco V-Mang is a drawn, heat-treated austenitic 14% manganese steel electrode containing approximately 1% molybdenum. Either bare or coated, it is

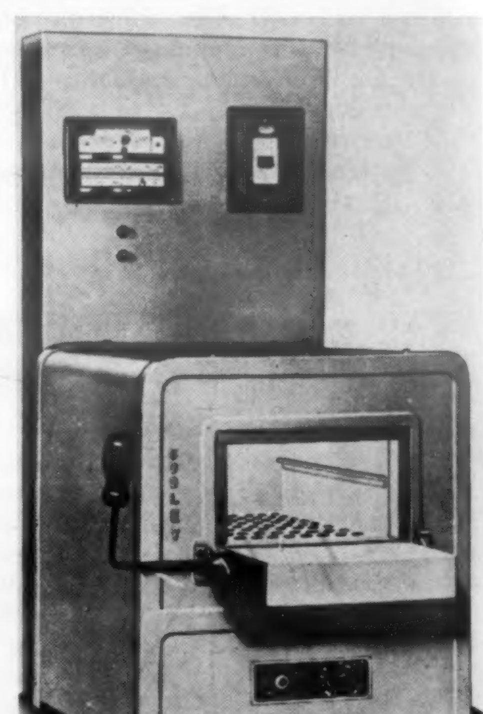
For more information, turn to Reader Service Card, Circle No. 319

said to produce a work hardenable austenitic deposit superior to nickel-manganese type electrodes. The company says that yield strength, crack resistance and weldability have been improved with this analysis.

V-Mang should be peened as deposited. The base metal should not be overheated as continued heating at moderate temperatures tends to cause embrittlement in manganese steel castings. For this reason arc welding should always be used on austenitic manganese steel. Weld deposits have great toughness and ductility, and the surface will work-harden to 450-550 Brinell.

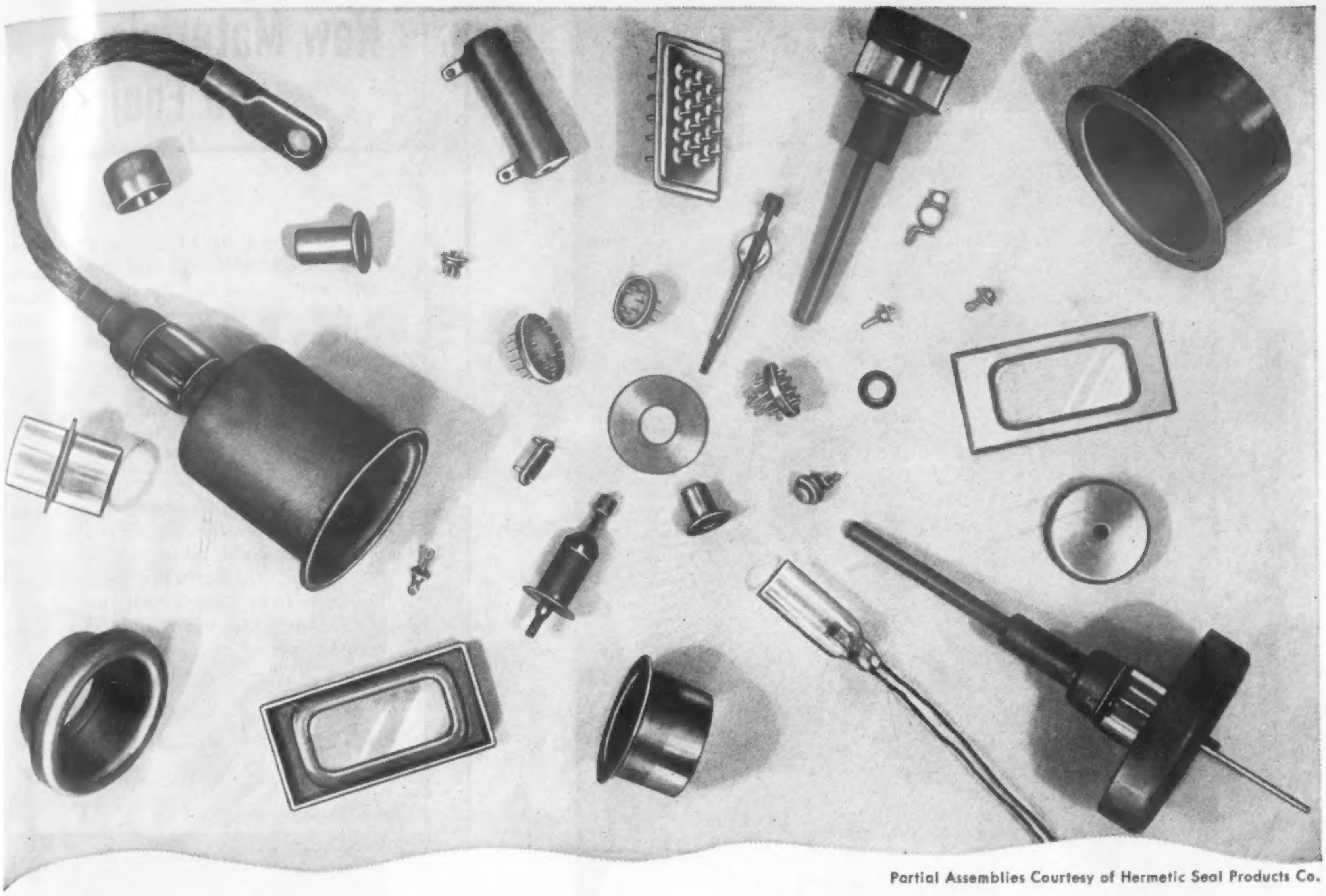
The new rod is recommended for repair and build-up work on manganese steel castings where severe impact is the primary cause of wear. Some typical applications would be dipper teeth, bucket fronts, keepers, crusher rolls, coupling boxes, spindles, coal crusher segments, bucket lips, etc.

The rod is supplied in 18 in. lengths, in diameters of 5/32, 3/16, and ¼ in., bare or coated. It is also available for automatic welding.



Small Heat Treat Furnace Allows Batch Treatment of Parts

A small, recirculating air, draw furnace, said to have performance characteristics of large convection type furnaces has been marketed by *Cooley Electric Mfg. Corp.*, 38 S. Shelby St., Indianapolis, Indiana. Models ACH and ACH-2, with chamber



Partial Assemblies Courtesy of Hermetic Seal Products Co.

For more information, turn to Reader Service Card, Circle No. 432

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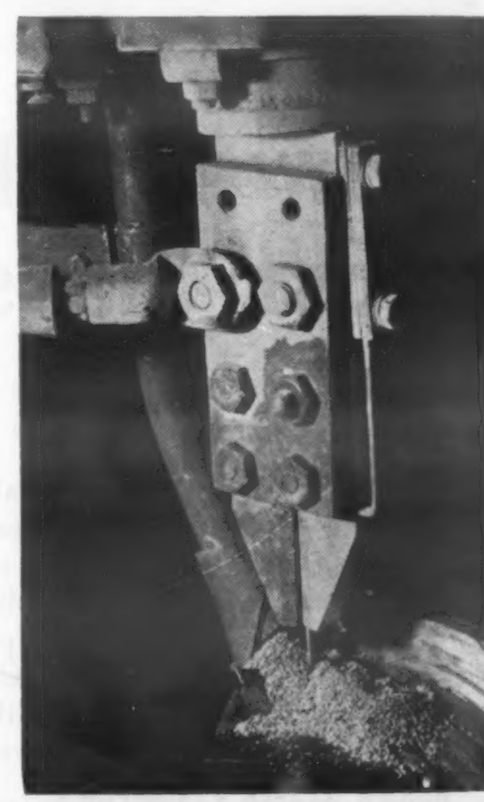
sizes of 8 by 6 by 14 in. and 12 by 8 by 18 in. respectively, are said to be particularly well suited for the batch treatment of aluminum rivets, tempering of steel, and other operations requiring accurate low temperature control.

Below the perforated hearth a fan is located which directs the furnace atmosphere outward to baffled side sections, upward behind these baffles, past the elements, over the top and into the chamber. The air is thus forced through the work and returned to the fan. This convection provides uniform absorption of heat by the charge. Baffle walls prevent direct radiation from the elements to the work surface, avoiding overheating and uneven temperatures.



Alloy Containing Fluxes for Automatic Hardsurfacing

A new technique for automatic hardsurfacing in which the alloy content of the deposited metal is supplied by an agglomerated granular flux rather than by the electrode has been developed by the *Lincoln Electric Co.*, Cleveland, Ohio.

With this new method, it is possible to apply automatic hardsurfacing with conventional mild steel electrodes by substituting the new hardsurfacing flux for the mild steel flux normally used. Any standard automatic welding head may be used, and the manufacturer states that all the advantages of hidden arc welding

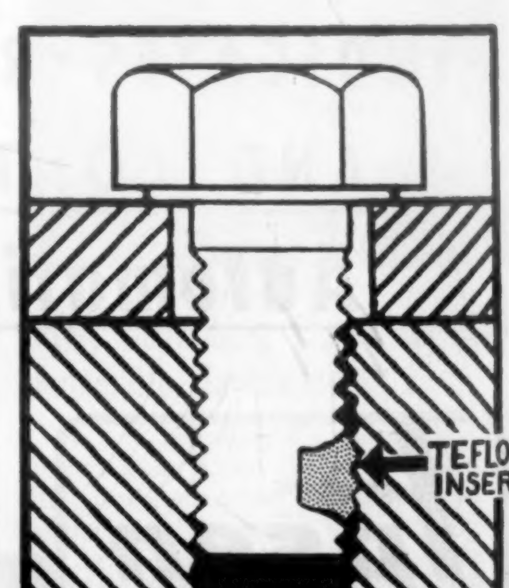
New Materials and Equipment

are retained. Hardsurfacing properties can be matched to service requirements by diluting the flux as necessary with mild steel flux. The company has marketed two hardsurfacing fluxes: Flux H-545 and H-550.

Flux H-545 is designed to provide a smooth layer with good abrasion resistance and high impact strength. It is used for deposits to be forged, such as plow share blanks; for metal to metal wear, such as tractor rollers or crane wheels; or for smooth deposits without porosity and underbead cracking, such as steel mill roughing rolls which do not require machining. The weld metal is an alloy of carbon, manganese, silicon, chromium, molybdenum and vanadium. The resulting deposit is magnetic at room temperature and with recommended procedures has a consistant hardness of 53-57 Rockwell C.

Flux H-550 is designed to provide extremely abrasion resistant deposits with good impact strength, for applications such as crusher rolls, crusher liners, scraper blades, etc. The weld metal is an alloy of carbon, manganese, silicon, chromium, and molybdenum. The deposit is magnetic, semi-austenitic at room temperature and with recommended procedures a broad range of 36-62 Rockwell C can be developed.

Both of the new hardsurfacing fluxes can be used with a medium to high carbon electrode as well as with a mild steel electrode.



Nylon Insert Locks Screws and Bolts

A nylon insert which conforms to the curvature of the screw or bolt threads provides a positive locking action on the

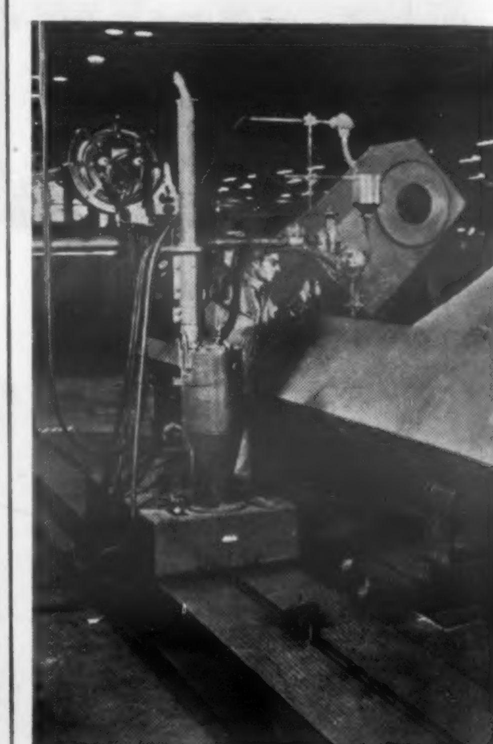
For more information, Circle No. 436 ➤

New Materials and Equipment

Holtite-Nylock, one-piece screws and bolts. Developed by the *Continental Screw Co.*, New Bedford, Mass., the screws and bolts are said to lock smoothly, allowing re-use again and again.

Other advantages claimed by the manufacturer are:

1. The positive locking eliminates safety wire, lock washers, jam nuts, etc.
2. Locks when seated or unseated.
3. Acts as a seal for gases or liquids.
4. Does not harm mating thread parts.
5. The screw or bolt is in one piece, reducing inventory, purchasing and receiving problems.
6. Can be used on soft metals, such as aluminum and die castings without damaging them.
7. Can be used at temperatures from —50 F. to 250 F.



Automatic Welding Machine Speeds Work on Large Structural Parts

Welding engineers of the *National Supply Co.*, Torrance, Calif. have developed a versatile and relatively simple automatic welding machine for welding large structural parts such as the frame of the Hufford stretch press shown above.

The unit is a submerged-melt welding machine incorporating a standard head from an older type machine. The base and track assembly is adjustable to facilitate alignment with the work, and addi-

For more information, turn to Reader Service Card, Circle No. 405

New Materials and Equipment

tional track sections may be added for working on longer parts. The position of the welding head is adjustable vertically and laterally on the carriage, and angular positions are provided by hinging the head on the end of the horizontal supporting arm. The welding speed is controlled by varying the speed of the carriage. Two 600 amp welding generators supply current to welding wire 3/32 to 1/4 in. dia and the flux is fed by compressed air.

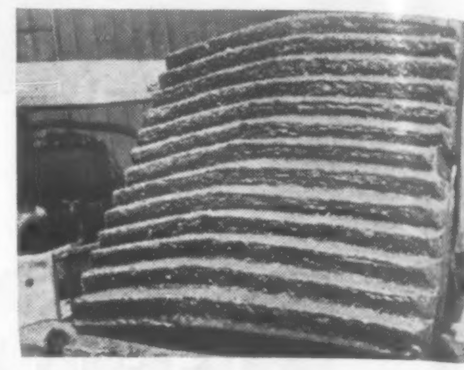
Electric Box-Type Heat Treating Furnace

A new high temperature electric heat treating furnace has been marketed by *K. H. Huppert Co.*, 6830 S. Cottage Grove Ave., Chicago. Designed with a skirt type cabinet, the new KR series is available in five different sizes, from 6 by 6 by 9 in. to 10 by 8 by 18 in. and is furnished with transformer, contactors, switch box, and electric indicating temperature controller.

Providing a temperature range of 300 to 2000 F, the heating elements are made of high temperature alloy wire which is said to be non-scaling, non-flaking, and practically impervious to attack from sulfur and its compounds.

For more information, Circle No. 439

New Materials and Equipment



Electrode Provides Heat for Metal Working Processes

Designed, not for welding, but as a source of instant heat where the use of an acetylene torch is impractical, the ThermoTrode rod is marketed for use in pre-heating, annealing, heat treating, softening, or burning off of paint. Instead of depositing the metal, it is oxidized so that the core metal disintegrates into a powder that can be easily brushed off.

Developed by *Eutectic Welding Alloys Corp.*, 40-40 172 St., Flushing, N. Y., the rod can be used in an ordinary electrode holder of a d.c. arc welder and the heat may be applied over a wide area by a circular or weaving motion. Pre-heating of the base metal or heating after welding to relieve stresses can be accomplished by replacing the welding electrode in the holder with a ThermoTrode rod. It is available in either 1/8, 5/32 and 3/16 in dia.

Hot-Cold Test Unit Operates from —130 to 250 F

A new unit for high and low temperature testing is now available from *Sub-Zero Products Co.*, Reading Rd. at Paddock, Cincinnati. Available in capacities from 1 to 4 cu ft, the new unit will operate at temperatures from —130 to 250 F.

For low temperature operation, the standard Sub-Zero Heat Sponge design is used, while an automatically controlled, water-proof, explosion-proof heater is used for the high temperature range. Either manual or automatic temperature control can be provided.

The test chamber of the unit is equipped with a fan for controlled air flow and uniform temperature distribution. A temperature recorder is also provided with the unit.

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Application — Deep drawing die for steel

Major Class — Metal Forming — Cold

Sub-Group — Special Purpose

Tool Characteristics — Wear Resistance

Tool Steel — Airdi 150

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TOOL STEELS

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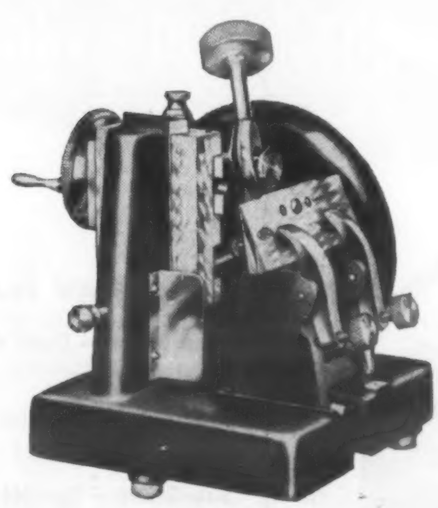
• For more information, turn to Reader Service Card, Circle No. 369



New Materials and Equipment

Corrosion Resistant Paint for Outdoor Applications

A new paint, called Super-Melaglyp, has been developed for outdoor applications by *General Electric's Transformer Div.*, Schenectady, N. Y. Now being applied to all G-E transformers, regulators and capacitors, the new paint is said to have improved resistance to salt spray, humidity, and chemical fumes.

Tests of the paint show that Super-Melaglyp withstands salt spray exposure for 1400 hr—twice as long as the Melaglyp previously used. It shows a 25% improvement in weather durability, a 35% improvement in chemical resistance, a 50% improvement in resistance to humidity, and a 20% improvement in color retention.

Pressure-Sensitive Tape Will Stand Oven Heat

A pressure-sensitive masking tape for the metal finishing industry, designed to withstand oven temperatures of 325 F, has been developed by *Minnesota Mining and Mfg. Co.*, 900 Fauquier St., St. Paul. The "Scotch" brand, high temperature masking tape No. 214 is particularly designed for use on such treated metals as anodized aluminum, pickeled steel and dichromated magnesium, and according to the manufacturer is capable of withstanding longer bake cycles than previously possible.

The tape will remove cleanly from the metal surfaces, leaving no adhesive deposit. It is available in 1/4 to 36 in. widths in 60 yd rolls.

All-Purpose Automatic Welding Machine

Leader Welding and Mfg. Co., 2418 Sixth St., Berkeley, Calif., has marketed the Leader Model 700 which has a heavy duty head, with a 1200 amp d.c. current source. It can also be used individually as three 400-amp manual welders.

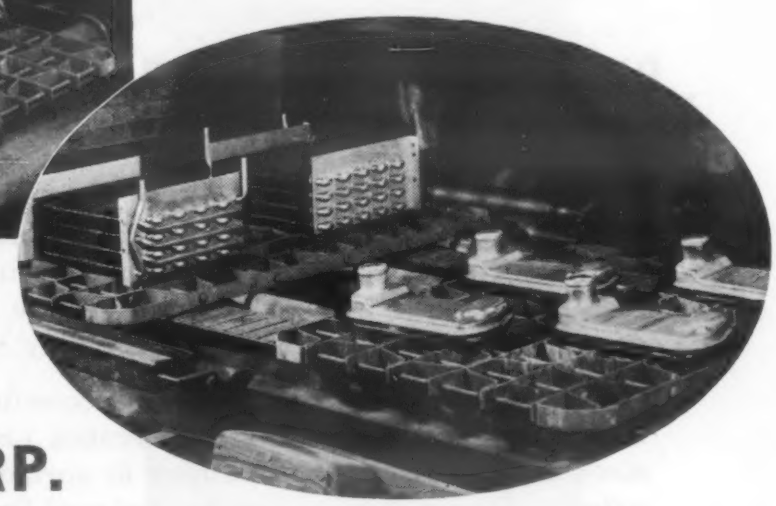
The machine has an operator's control located on the horizontal cross-bar, as well as the main control panel. The ped-

ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

● Rolock "Serpentine" Trays carry Condenser Units on powered rollers thru furnace, for brazing at 2050°F.



BRAZING TRAY life increased 140%
...Maintenance *decreased* 100%

...*at* FEDDERS-QUIGAN CORP.

Rolock "Serpentine" furnace trays, built for this specific use, were furnished in two sizes...24" x 30" (weight 22 lbs.) and 24" x 36" (26 lbs.). The maximum load carried by the larger tray is 80 lbs.... in brazing, an exceptionally good ratio of load to weight. Some trays are of type 330 stainless, others are of Incoloy.

Trays formerly used had a maximum life of 2500 trips thru the furnace. Rolock trays give a minimum of 6000 trips...then are rebuilt for additional service.

Former trays required maintenance by one full-time skilled worker and a part-time helper; "Serpentine" have required absolutely no maintenance. Moreover, other trays frequently jammed in the furnace, causing costly down-time of the whole line. "Serpentine," no jamming, no down-time.

The answer, of course, is in the fully articulated "Serpentine" construction which resists warping to the highest degree. If this is one of your problems, write Rolock for practical solutions.

Send for Catalogs B-8 (Heat Treating) or B-9 (Corrosion Resistant)

Offices in: PHILADELPHIA, CLEVELAND, DETROIT, HOUSTON, CHICAGO, ST. LOUIS, LOS ANGELES, MINNEAPOLIS, PITTSBURGH

ROLOCK INC. · 1282 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

7RL53A

For more information, turn to Reader Service Card, Circle No. 316

estal is motorized and has a 96-in. travel. It rotates through 360 deg and has built-in locking and limit switch controls.

The 132-in. cross-arm has an acme-actuated, variable speed reversible drive motor (20-1 ratio) for carriage traverse, and limit controls are built in.

The company claims that other features include manual and automatic bead lapping control; rapid traverse control; free wheeling clutch; lead adjustment and angling device for the bead; dual 500-lb capacity flux bins which are mounted on casters; the standard P3000 Leader positioner; a standard vacuum flux recovery system; and dual, adjustable, spring-braked reel holders capable of holding 250 lb of wire.

All wiring is furnished and executed to facilitate 3-phase, 220/440 v, 225/115 amp connection at point of installation.

Microscope-Reader Aids in Metal Hardness Measurements

A new Brinell microscope-reader for the measurement of the diameters of indentations made by the ball indentors of all Brinell type hardness testing machines is being produced by the *Pacific Transducer Corp.*, 11921 W. Pico Blvd., Los Angeles. As well as aiding in the determination of the hardness of a metal, the instrument is said to be useful in checking the accuracy of hardness testing machines.

The Brinell microscope features a reticle in a flat-field optical system and a self-enclosed beam of light. It provides a clear image of the indentation with the sharp image of the reticle superimposed. The scale is calibrated in millimeters and tenths of millimeters. The total length of the scale is 7 mm, and the field of the microscope is 7.5 mm dia. Illumination for the indentation field is supplied by a pre-focused battery-type illuminator. The instrument has a magnification of 20 dia, which makes it suitable for shop or laboratory uses wherever medium magnification is required.

For more information, Circle No. 374 ➤

News of Engineers

Carboloy Dept., General Electric Co., has announced the following appointments: *Eugene J. Lenar,* formerly with Eastern Michigan Steel Foundry Co., as an engineer in the metallurgical process and quality control unit for permanent magnet materials at the Edmore, Mich. plant; *Roy C. Nichols,* formerly with Diesel Equipment Div., General Motors, as an engineer in the above unit at the Edmore plant; *Gordon H. Gillis,* formerly superintendent of heat treating at Kropp Forge Ordnance Co., as a heat treating engineer for coal mining tools in the carbide process and development section; and *Barnard E. Speranza,* a metallurgical engineer with General Electrical Co.'s chemical and metallurgical training program, as an engineer in the carbide materials development section.

General Electric Co. has announced the following appointments: *Arthur F. Vinson* to serve as vice president of manufacturing and as general manager of the company's Manufacturing Services Div., succeeding *Nicholas M. DuChemin* who will serve as vice president on special assignments for the president; *Dr. Louis T. Radar* as general manager of the company's new Specialty Control Dept. at Schenectady; *K. N. Bush* as manager of manufacturing, *H. L. Palmer* as manager of engineering, and *J. P. Rutherford* as manager of marketing, all in the new department; *H. Arthur Howe,* manager of the laminated plastics plant in Pittsfield, as manufacturing manager of the Laminated and Insulating Products Dept.

Robert B. Duthie has been named general manager of the Modern Process Plating Co., a subsidiary of Viking Air Conditioning Co.

James H. Moore, formerly director of metallurgical research for National Research Corp., has been appointed general manager of Vacuum Metals Corp., a wholly-owned subsidiary of National Research Corp.

Samuel N. Comly, vice president and treasurer of Russell, Burdsall & Ward Bolt and Nut Co., has been granted a leave to serve as assistant administrator of the National Production Authority, U. S. Dept. of Commerce.

Dr. Joseph Varimbi has joined the Edison Laboratory chemical research group. Dr. Varimbi's major project will be research in the battery field.

Appointment of *Clark Langworthy* as chief engineer for industrial hydraulic products, Parker Appliance Co., has been announced.

S. M. Jenks has been named to the newly-created post of assistant executive vice president—operations, United States Steel Corp. At the same time it was announced that *John M. Elliott* has been appointed vice president, operations—steel, succeeding Mr. Jenks, and *E. H. Gott* has been made general manager, operations—steel, succeeding Mr. Elliott.

Julius J. Harwood, deputy head of the

◄ For more information, Circle No. 453

News of Engineers

Metallurgy Branch, Office of Naval Research, Navy Dept., has been appointed head, Metallurgy Branch. Mr. Harwood replaces *Dr. O. T. Marzke* who has returned to the Naval Research Laboratory as associate director.

A. B. Capron, formerly chief engineer, has been named assistant works manager in charge of the tube mills and engineering, and *Newell Hamilton,* formerly superintendent of the steel mill, has been appointed manager of steel operations in the Tubular Products Div., The Babcock & Wilcox Co.

Thomas J. Pashos and *David B. Wehmeyer* have rejoined Monsanto Chemical Co.'s atomic electric project which is sponsored jointly by Union Electric Co. of Missouri. At the same time it was announced that *Dr. Leon Cooper,* formerly with the Oak Ridge National Laboratories, has also become a member of the group.

Marvin A. Joy, manager of sales services, Chase Brass and Copper, has been appointed director of the Copper Div., National Production Authority, U. S. Dept. of Commerce. Mr. Joy succeeds *Joseph F. Miller,* who has been with NPA since 1950.

Joseph H. Pargeter has been named head of the steel forge operation of Willy Motors.

Allan V. DeMarco has been named general manager of Hills-McCanna Co.'s Foundry Div.

William C. Imholz has been named to head the West Coast plastics technical service group of the Naugatuck Chemical Div., U. S. Rubber Co.

Metal Hydrides, Inc. has announced the following appointments: *Robert C. Wade* as assistant director of the Chemical Research Laboratory, and *Robert D. Gray* as factory superintendent.

S. W. Antoville has been elected president of United States Plywood Corp. In this post he succeeds, *Lawrence Ottinger* who remains as chairman of the board and chief executive officer.

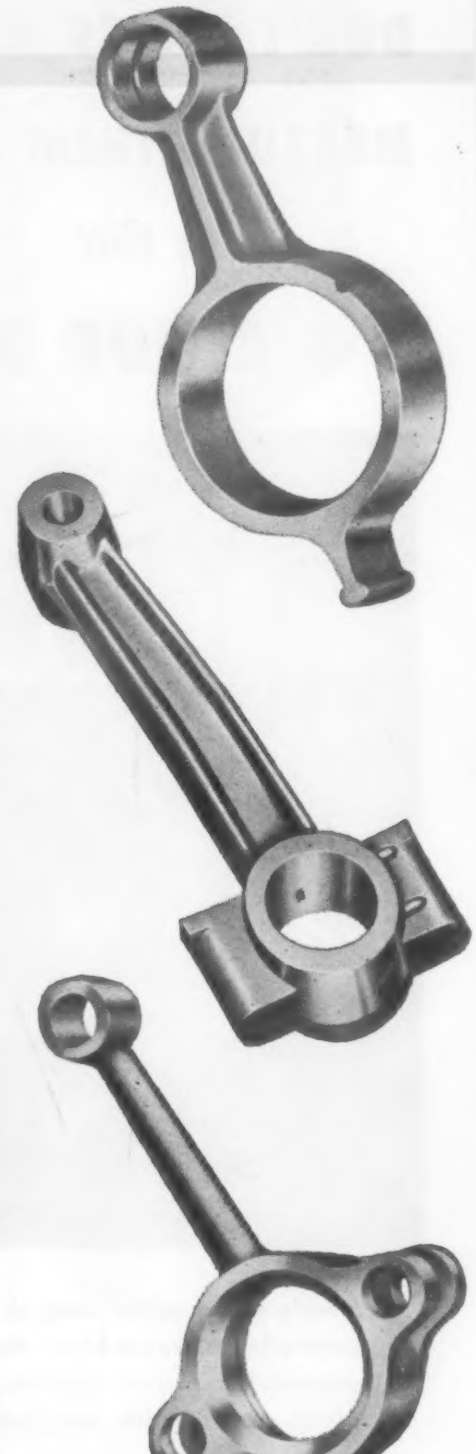
Donald V. Sarbach has been named technical manager of New Products Development Dept., The B. F. Goodrich Co.

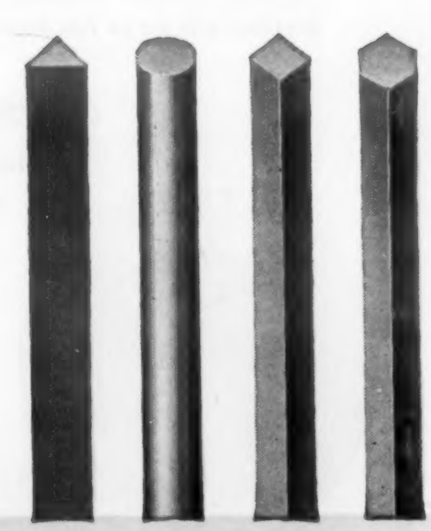
J. S. Fawcett has been named director of Fisher Scientific Co.'s Development Laboratories.

Clair S. Reed has been elected vice president, director and a member of the executive committee of the United Metal Craft Co., a subsidiary of Gar Wood Industries, Inc.

William H. Yeckley has been appointed general manager of steel operations for The Youngstown Sheet and Tube Co., and *Walter J. Prochak* has been named assistant superintendent of the Cold Drawn Bar Dept. at the company's Brier Hill works.

Seward H. French, Jr. has been elected





News of Engineers

a vice president of Crucible Steel Co. of America.

Bohn Aluminum & Brass Corp. has announced the following appointments: *Guy Pitts*, formerly plant manager of company plants 5 and 8 has been appointed division manager of the Brass and Bronze Div., and *David Walters* has been named chief industrial engineer.

W. Monroe Wells, a veteran of 35 years in the aluminum industry, has been named assistant vice president in charge of operations, Reynolds Metals Co.

The following appointments have been announced by Armour Research Foundation, Illinois Institute of Technology: *Dr. Kurt Peter Anderko* has been made full research metallurgist; *Dr. Frank Lerman*, formerly acting supervisor of chemical engineering in the department of chemistry and chemical engineering, will work with the research advisor in the maintenance and improvement of the technical and professional status of the Foundation.

Dr. Newman W. Thibeault has been named assistant director of research and development in charge of the Physical Research and Microscopic Sections by Norton Co. Dr. Thibeault succeeds the late *A. Albert Klein*.

A. H. Tinnerman, president, Tinnerman Products, Inc., has been elected chairman of the board, and *George J. Schad*, vice president, has been named as president.

Caterpillar Tractor Co. has announced the following personnel changes: *G. E. Burks*, formerly chief engineer of the Peoria plant, has been made director of engineering; *John E. Jass* will succeed Mr. Burks, and *Paul B. Benner* will become assistant chief engineer at the Peoria plant with supervision over design of motor graders and wheel tractors; *Carl L. Kepner* will become assistant chief engineer with supervision of earth-moving equipment now manufactured at the Joliet plant.

Merle Newkirk, a member of The Dow Chemical Co.'s Power Dept. for the past 38 years will retire from active service, but will continue to serve the department as a consultant. At the same time it was announced that *Macauley Whiting* has been appointed as Midland Div. power manager, and that *Leo L. Moran* has been made operating manager in direct charge of all Midland power operations. A new employee classification with the title, research specialist, has been established by the company, and *Dr. L. K. Frevel* of the Spectroscopy Laboratory has been named as the first scientist accorded that rank.

Appointment of *Everett G. Fahlnan*, president, The Permold Co., as deputy director of the Aluminum Div., has been announced by the National Production Authority, Dept. of Commerce.

A. C. Richardson, who has had supervisory charge of research in mineral processing at Batelle Institute, for the

THE HOW, WHEN *and* WHERE

of Spencer Turbo Air-

If you need air for heat treating, or large volumes of air for cooling, drying, or chemical agitation, you need these two new Spencer Data Books.

No. 107-C The Turbo Compressor Data Book gives a wealth of experience in pneumatic engineering, including orifice equivalents, equalization of pipes, effect of pressures and altitudes and friction losses.

No. 126-A describes the Spencer Turbo-Compressor, lists more than 160 standard capacities from 1/3 h.p. up, including electric, gas engine, turbine and belt driven units.

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440-A

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CODE OF ETHICS SIGNER
GAS APPLIANCE MANUFACTURERS ASSOCIATION
SIGNED NO. 29

35 TO 20,000 C.F.M.; 4 OZ. TO 10 LBS.; 1/3 TO 1,000 H.P.

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News of Engineers

past twenty years, has been named a technical director. Mr. Richardson, with the Institute's other directors, will be responsible for the technical guidance of Battelle's research program for industry and government.

W. J. Adams, Jr. has been promoted to the Central Engineering Dept., Food Machinery and Chemical Corp., San Jose, Calif. He is being replaced in Port Washington by *M. D. Burrows*, chief engineer.

Donald W. Withrow has been appointed methods engineer for Electro Refractories & Abrasives Corp.

C. C. Hurlburt has joined the Welding Div., P. R. Mallory & Co., Inc.

John W. Pennington has been named manager of the new Technical Dept. of the Metal Products Div., Koppers Co., Inc. Mr. Pennington joined Koppers in 1950 as chief engineer of the Piston Ring Dept., and since 1952 has held the post of executive engineer for the entire Metal Products Div. The company also announced the appointments of *A. D. L. Orefice* as chief engineer, and *G. F. Ross* as assistant chief engineer of the Coke Plant Dept.

Wesley E. Weber has been named development engineer at Furane Plastics, Inc.

Election of *Roy J. Gavin* as a vice president of Irvington Varnish & Insulator Div. of Minnesota Mining & Mfg. Co. has been announced.

J. T. Dugall has been appointed to the newly-created position of rod, bar and wire operations manager for Kaiser Aluminum & Chemical Corp., and *C. W. Heppenstall* has been named plant manager of the rod, bar and wire works at Newark, Ohio.

Elmer H. Wegner, formerly acting works manager, has been appointed general manager of manufacturing for Cleaver-Brooks Co. Aiding Mr. Wegner will be *Glenn W. Leupold* as works manager.

Appointments of *B. P. Gibbons* to the newly-created position of manager of material, and *Paul G. Osborn* as factory manager of Plant I at Convair's San Diego division, were announced by Consolidated Vultee Aircraft Corp.

Appointment of *James H. Bly*, formerly supervisor of radiography and Electronics in the Materials Control Laboratory of Pratt & Whitney Aircraft, as research director of X-Ray Inc., has been announced.

Theodore W. Rundell has been appointed vice president in charge of operations at Servel, Inc.

Died . . . .

Donald H. Montgomery, vice-president and director of The New Britain Machine Co.

Henry W. Bartling, application engineer in charge of the metal industries group of Allis-Chalmers Mfg. Co.'s motor

News of Engineers

and generator section.

A. Albert Klein, assistant director of research and development at Norton Co.

Harry Merrick Reed, a member of the board of directors of Vanadium-Alloys Steel Co., and secretary of both Vanadium-Alloys and its subsidiary Anchor Drawn Steel Co.

J. Irvin Schultz, vice president and treasurer of National Broach & Machine Co.

News of Companies

Jacobson Mfg. Co., Inc. has announced the purchase of *Nut Mfg. Div., Eagle Lock Co.*

Formation of two new autonomous divisions have been announced by *Diamond Alkali Co., The Plastics and Agricultural Chemicals Div.,* and the *Chromium Chemicals Div.*

Construction of a 19,600 sq ft fireproof steel building which will replace one recently razed by fire, is scheduled to start soon at the gray iron foundry of *Lindgren Foundry Co.*

A new modern manufacturing plant is being constructed by *Barrett-Craven Co.* at Northbrook, Ill. The 150,000 sq ft works will be ready for occupancy in April, 1954, and will cost approximately $1,000,000.

Formation of an *Application Research Department* and broadening of activities of the *Development Department* of *Monsanto Chemical Co.'s Merchandising Div.* have been announced. At the same time, J. C. Harris, who had been assistant research director of the Central Research Dept., was named director of the new research group which will be located at the Central Research Dept. in Dayton.

The Pennsylvania Salt Mfg. Co. has entered into the field of chemical specialties for phosphatizing metals for corrosion resistance and paint bonding with a complete line of products for this field under the trade name Fosbond.

The Chester, N. Y. plant of *Chester Cable Corp.* will soon have 25,000 sq ft of additional plant area in full production. The new wing, housing extensive additions to plant and equipment, will help meet the increasing demand for products in the industrial and commercial wire fields.

Certified Alloys Co. has announced the opening of a new and modern alloying plant in the Los Angeles area.

A new $3 million mine and plant to produce ilmenite, the raw material for titanium metal and pigments, will be constructed for the *Du Pont Co.* near Lawtey, in north central Florida. Construction will start within the next six weeks, and the schedule calls for complet-

For more information, turn to Reader Service Card, Circle No. 442

News of Companies

ing the installation and getting it into operation early in 1955.

Harper-Leader, Inc., 1046 S. Main St., Waterbury, Conn., was recently established by Perry J. Sloane and I. Cross. The company will specialize in precision plating of some precious metals such as gold, silver, platinum, rhodium and palladium.

A new 10,000 sq ft addition to the *Monroe Tube Co., Inc.* plant at Monroe, N. Y. has been completed.

The country's first aluminum skyscraper —the 410 ft Alcoa Bldg. in the heart of Pittsburgh's Golden Triangle—was recently dedicated marking completion of the lightest building for its size ever built. Twenty-five floors of the ultra-modern, 30-story structure are now occupied by *Aluminum Co. of America;* the balance has been rented to tenants.

The Furnace Div. of *R-S Products Corp.* has announced its incorporation, and will be known in the future as *R-S Furnace Corp.,* a subsidiary of *Hardinge Co., Inc.*

The Rod Cutting Co. of Cleveland, has changed its name to *The Cayce Corp.*

United Stove Co. voted at a recent meeting to change its name to *United Metal Craft Co.*

National Welding Equipment Co. has announced the purchase of buildings adjacent to their present plants. Of the newly acquired 16,000 sq ft of buildings, some 1700 sq ft will be used for display; the shop will be enlarged by nearly 10,000 sq ft and the engineering and development departments, by 2200 sq ft.

Vanton Pump Corp. has changed its name to *Vanton Pump & Equipment Corp.* At the same time it was announced that the Vanton manufacturing plant has been moved from its present location in Long Island City to a new building on the premises of its affiliate company, *The Cooper Alloy Foundry Co.,* Hillside, N. J.

Diversey Corp. has announced the purchase of the *Selcon Engineering and Chemical Co.,* Chippewa Falls, Wis.

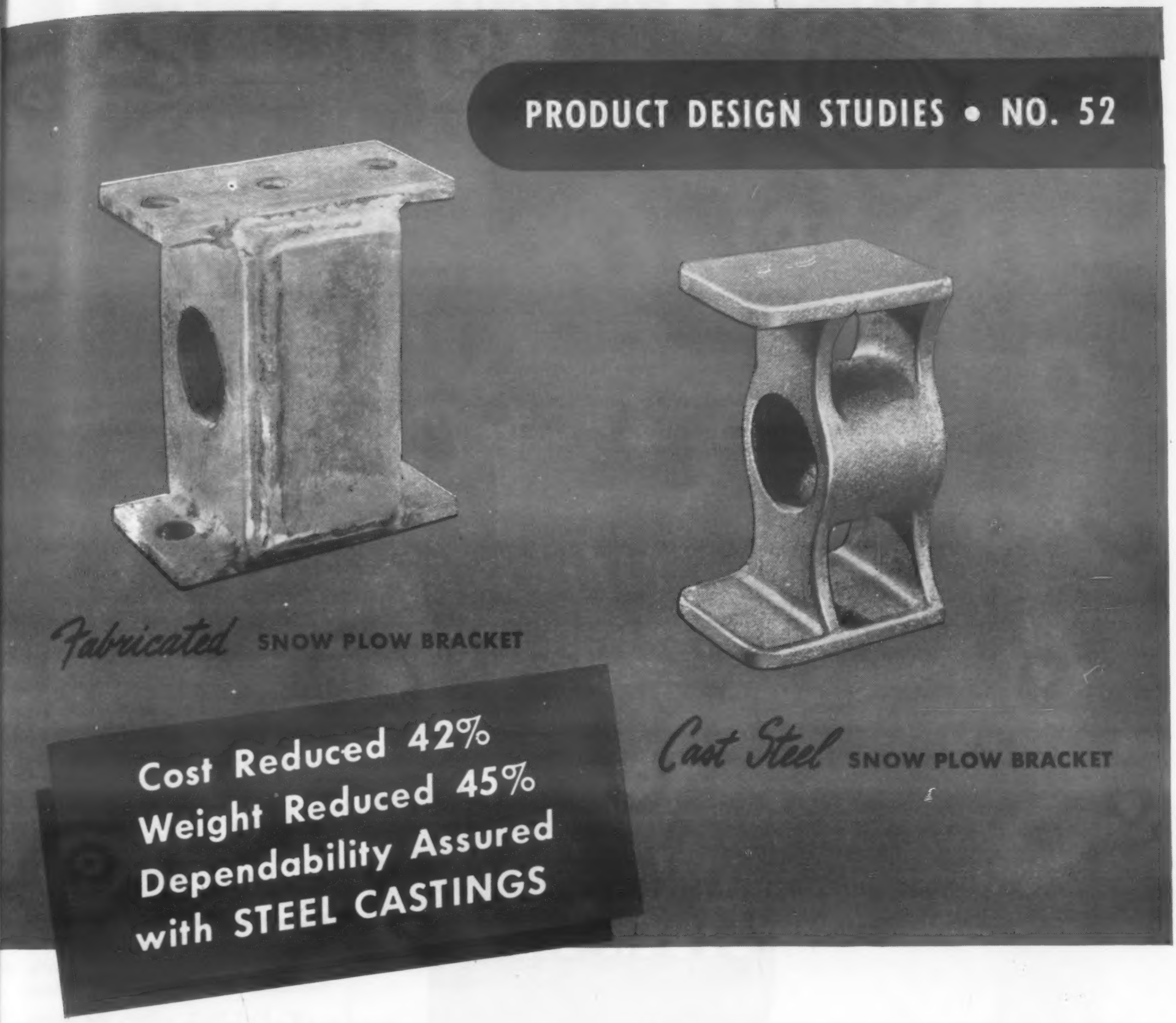
Formal opening of the *Hyster Co.'s* new European manufacturing facilities were recently celebrated in Nijmegen, The Netherlands.

Dunn Steel Div., Townsend Co., has started construction of a new plant at the firm's Plymouth, Mich. headquarters. The half million dollar project is expected to increase the Dunn Steel Div.'s capacity to produce special cold-headed fasteners for the automotive industry.

Youngstown Sheet and Tube Co. announced the acquisition of an interest in the *Perrault Fibercast Corp.*

Plans for an expanded research program, including a further addition to its laboratories, have been approved by the board of directors of *E. F. Houghton & Co.*

Westinghouse Electric Corp.'s Sunny-



The advantages obtained in converting this snow plow part from a weldment to a steel casting show what frequently can be accomplished when a manufacturer's engineering department and the steel foundry work closely together.

In this case, redesign to a steel casting resulted in a 42% savings in cost, and a reduction in weight of 45%—from 11 pounds to 6 pounds.

Other advantages obtained by producing this part as a *foundry engineered* steel casting are assured dependability and improved appearance.

* * *

Here is another example of the foundry cooperation which is resulting in lower costs and improved products through redesign to steel castings.

This service is offered without cost or obligation. It makes available through your foundry representative the full results of the development and research program carried on by the Steel Founders' Society of America.

Product Development Contest . . .

Two cash awards of $1000 each and four other awards—a total of $3500. Entries to be new ideas or applications of steel castings, and case histories of new jobs put into production. Write for folder giving full information.

51 YEARS OF SERVICE TO INDUSTRY

STEEL FOUNDERS' SOCIETY OF AMERICA

920 Midland Building — Cleveland 15, Ohio

Design and Build With Steel Castings

For more information, turn to Reader Service Card, Circle No. 488

News of Companies

vale, Calif. plant, the largest electrical manufacturing facility in the West, will operate in the future as a single unit under the managership of George F. Gayer. It will be known as the *Pacific Coast Mfg. Plant.*

A. F. Holden Co. has purchased the physical assets of *Cook Heat Treating Corp.,* Los Angeles. The business will be managed by Cook as a wholly owned subsidiary of A. F. Holden Co.

Consolidated Industries has announced completion of a new die shop designed to help meet the aircraft industry's growing demand for aluminum, titanium and alloy steel forgings.

News of Societies

E. L. Frantz, manager, Fiberglass Div., Apex Electrical Mfg. Co., has been named chairman of the *1954 Cleveland Plastics Conference Committee* of *The Society of the Plastics Industry, Inc.*

Manufacturers supplying the porcelain enamel industry with color oxides recently formed a division of the *Porcelain Enamel Institute.* It will officially be known as the *Color Manufacturers Div.* W. F. Wenning, Ceramic Color and Chemical Co., was elected chairman.

W. Earl Hall, editor, the Mason City Globe-Gazette, recently received the *Society of Automotive Engineers Beecroft Memorial Award* and presented the 1953 Beecroft lecture during the National Safety Congress held in Chicago.

American Die Casting Institute recently celebrated its 25th Anniversary at its annual meeting in Chicago.

P. Peter Kovatis was recently made executive secretary, *American Electroplaters Society.*

Clifford A. Hampel, chemical engineering consultant, has been elected president of the *Chicago Technical Council,* a federation of scientific, engineering, and technological societies.

A scholarship aimed at helping to produce more experts in the foundry field has been established by National Malleable nd Steel Castings Co. at the *Illinois Institute of Technology.* The new scholarship provides $500 a year.

Dr. George Russell Harrison, dean of science, *Massachusetts Institute of Technology,* was the recipient of an *Elliott Cresson Medal,* at the annual Medal Day ceremonies of *The Franklin Institute.* The award was made for Dr. Harrison's valuable work in spectroscopy.

For more information, Circle No. 304 ▸

For more information, turn to Reader Service Card, Circle No. 358

Aluminum-Magnesium casting with two test rods; one is still straight as-cast, the other bent to 90 deg.

New Bend Test for Aluminum-Magnesium Castings

. . . Insures customer that each part meets quality standards.

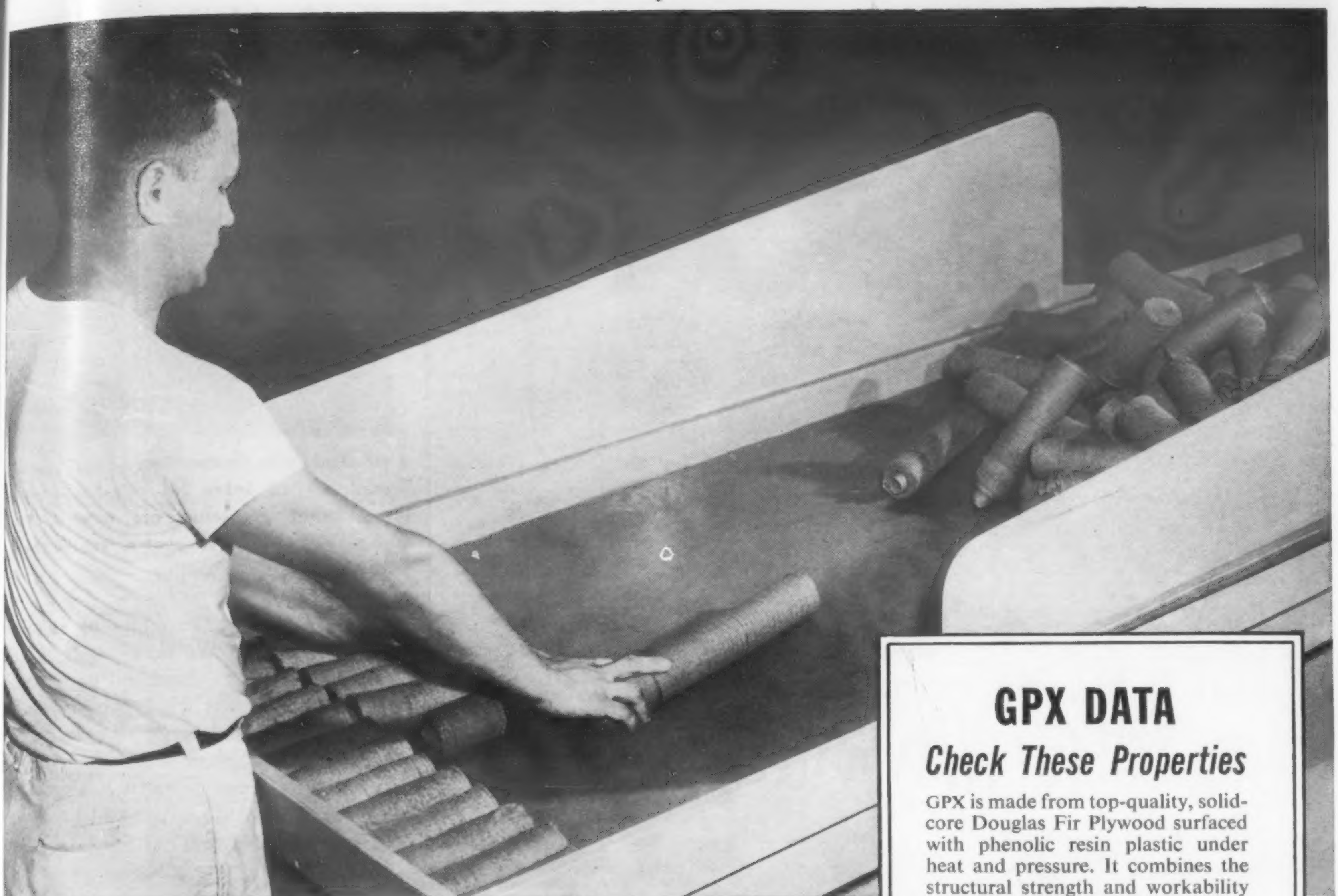
by WAYNE MARTIN, Vice President, General Aluminum Mfg. Co.

● IN THE PAST ten years the use of high strength aluminum-magnesium casting alloys has been growing more prevalent. Of these the Alcoa 220T4, after heat treatment, has the highest physical properties of any aluminum base, sand cast alloy. In the as-cast condition Alloy 220 is quite brittle and may easily be broken in handling. However, after a solution heat treatment and quench operation, this 10.3% magnesium alloy gains an ultimate strength of 50,000 psi, a yield strength of 25,000 psi and an elongation of 20%. With such a difference in physical properties before and after heat treatment, it is obvious that strict quality control is necessary on the part of the fabricator to insure that each Alloy 220 casting has been treated for optimum qualities before it leaves his plant.

Method

The General Aluminum Mfg. Co., which is now casting two Alloy 220 rudder brackets for the Canberra jet bomber, has found that though their inspection procedure employs 100% Zyglo and x-ray examination, these conventional methods still allow the possibility of an unheat-treated and completely unreliable part to be put in service. In order to provide a simple means of customer inspection

(Continued on page 188)



GPX DATA

Check These Properties

GPX is made from top-quality, solid-core Douglas Fir Plywood surfaced with phenolic resin plastic under heat and pressure. It combines the structural strength and workability of plywood with the hard, smooth surface-toughness of plastic, plus these unique properties:

WEATHER-RESISTANT... unaffected by sun, rain, or freezing.

WATER-RESISTANT . . . 20 times more resistant to water absorption than ordinary plywood.

ABRASION-RESISTANT... 10 times as abrasion-resistant as ordinary plywood in dry tests; 30 times when wet.

CHEMICAL-RESISTANT . . . resists hydrocarbons, alcohol, mild acids, organic solvents and acid fumes.

VERMIN-RESISTANT... armor-hard surface resists termites, marine borers, mold and fungi.

SMOOTH . . . remarkably smooth, highly resistant to checking and grain raise.

STRONG... plastic surface increases dimensional stability as well as overall strength.

EASY-TO-WORK . . . easy to saw, drill, sand, nail, rivet, glue or paint.

VARIETY OF GRADES AND WEIGHTS —comes in three grades: GPX GENERAL USE with a hard, smooth natural finish that never needs painting; GPX GREEN Painting Grade with the finest paint surface obtainable; and GPX CONCRETE FORM, known for maximum re-use and minimum refinishing. Within each grade is a complete range of thicknesses and overlay weights. Standard panel size is 4 x 8 feet.

SEND FOR FULL DETAILS TODAY

Snag-Proof • Splinter-Proof • Sanitary

GPX® PLASTIC-FACED PLYWOOD DOES A

BETTER JOB AT LESS COST

JOHNSON & JOHNSON, one of the nation's largest medical supply companies, solved material selection, finishing and maintenance problems at their New Brunswick, New Jersey plant with the unique features of low-cost GPX. Material packing benches made from GPX show no signs of wear despite the endless contact of thousands of bandages and cartons every day . . . the sparkling clean snag-proof surface makes GPX the ideal material for this use. In tables and cabinets, tough abrasion-resistant GPX never requires sanding, paint or varnish . . . needs just a wipe to keep them gleaming bright. When they wanted a material with structural strength, resistant to water, stain and many chemicals, JOHNSON & JOHNSON again turned to GPX to build a protective case for a delicate portable scale.

The uses of GPX now number well over 100, and new uses are being developed daily. Perhaps the answer to your problems lies in the unique properties of this miracle material. Write today for further information and descriptive data.

GEORGIA—PACIFIC
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DOUGLAS FIR PLYWOOD • G-P RIPPLEWOOD WALL PANELING

HARDWOOD PLYWOOD • GPX PLASTIC-FACED PLYWOOD • SOUTHERN & WESTERN LUMBER • DOORS

For more information, turn to Reader Service Card, Circle No. 426

New Bend Test . . .

continued from page 186

A sand cast magnesium wheel carrier used on F86 Sabre Jet. Full heat-treated mechanical properties are needed. The cast-on test rod is shown in the bent condition.

of each casting, the company is now casting one or two small rods, 3/16 in. dia and 1 in. long, on each part. If the rod is bent while the casting is in the untreated stage, the rod will snap off with glass-like brittleness. If the part has been properly heat treated to gain its optimum properties, the rod may be bent 90 deg without breaking. As the castings leave the foundry, the last operation is to bend the test rod or rods. If they break, the part is rejected; if they bend satisfactorily, the part is routed on to the customer. Upon arrival in the customer's plant, the presence of the bent rod on that part insures that the casting has been properly treated and is ready for service. The rods are placed in such a position that they may be easily removed by the customer's regular machining operations.

Reveals Other Weaknesses

This test rod method of inspection protects the user of the castings from hazards other than lack of heat treatment. There are several types of alloy contamination which are revealed by the bending of the rods.

In the case of sodium, for example, if a heat of Alloy 220 or AlMag 35 or Amalloy has been properly melted and good test bars poured and then if a conventional aluminum melting flux containing a sodium salt is used before the castings are poured, the heat will be contaminated by the sodium and unusable. The resulting castings will have an ultimate strength of only 17,000 psi, and 1% elongation. In this case, the test bars will look good, but the cast-on rods will be broken in the bend test and the sub-standard properties revealed. The same condition could result from accidental silicon contamination, which might raise the silicon content of the

WAUKESHA's 321

(titanium stabilized)

STAINLESS STEEL CASTINGS

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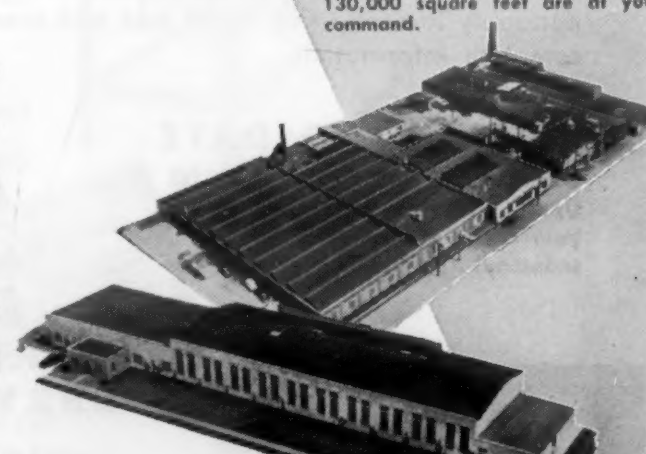

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New Bend Test . . .

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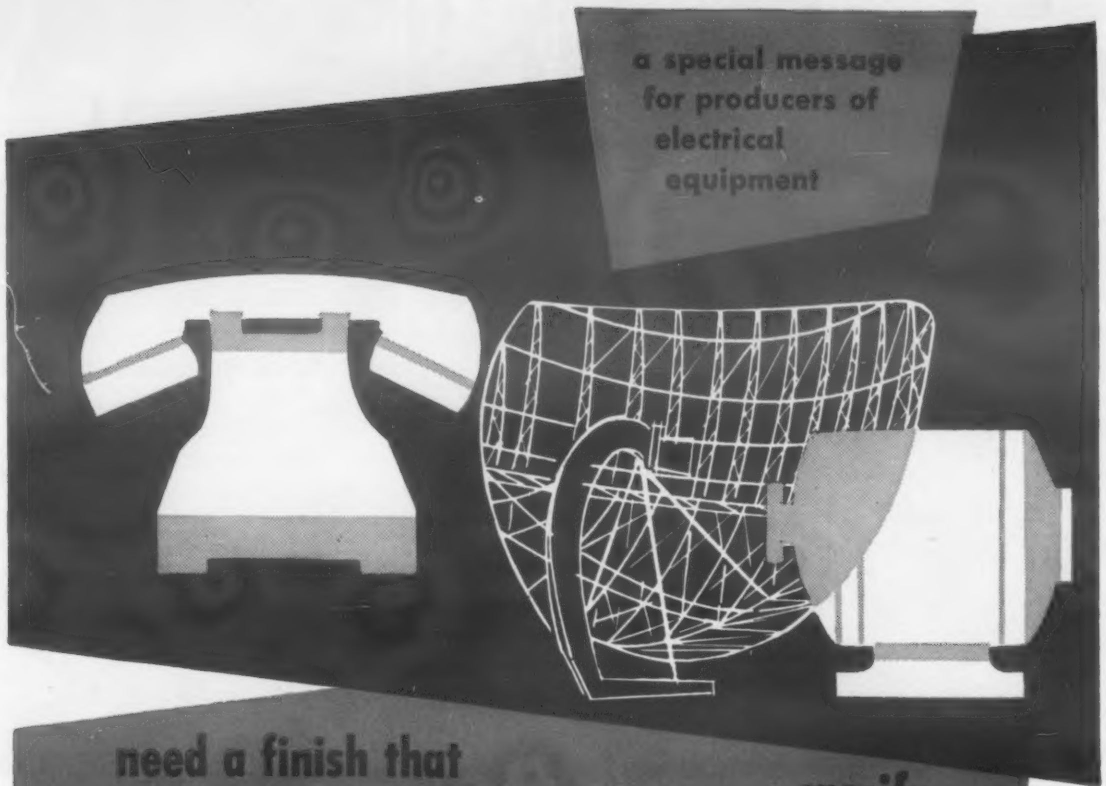
heat above the maximum allowable 0.15%. The bend test would again insure rejection of the deficient part.

This quality control technique is also used to reveal other hazards encountered with AlMag 35 and Amalloy, both of which are used in the as-cast condition since their properties are ruined by heat treatment in the range of 350 to 600 F. If heat and test bars have been properly made but large and hard to remove sand cores are used in the casting, the conventional method of removal would be to place the casting into the core oven to be baked until the core disintegrates. If the foundry layman does not put the test bars in with the casting, again the test bars would look good, but due to the oven heat the casting itself would have an ultimate strength of only 17,000 psi with 1% elongation. The test rod on the casting would break when bent and the casting would be scrapped.

Another alloy which would lend itself well to this inspection method is the magnesium base alloy, Dow C (AZ92). As-heat-treated in the HT condition, this alloy has properties of 40,000 psi ultimate, and 10% elongation. However, as-cast, it has an ultimate strength of only 28,000 psi and 1% elongation. Its use in the HT condition is now being specified on wheel and brake assemblies on many of our military aircraft. The incorporation of this bend test will eliminate the possibility of the foundry shipping untreated or deficient castings and give the customer positive assurance that each part meets the established standards.



Technical Reports on Materials

Ferrous

INTERNAL AND EXTERNAL HOT TEARS—THEIR DISSIMILARITY AS TO APPEARANCE, ORIGIN AND MEANS OF ELIMINATION. *H. F. Bishop, U. S. Naval Research Laboratory, 1946. PB 109497, 25 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75. Limited supply available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C., $.75.* Differentiation in photomicrographic appearance of internal and external hot tears in castings. Examples of both types are illustrated and discussed.

IMPACT PROPERTIES OF COMMERCIALLY AVAILABLE STRESS AT HIGH HARDNESS LEVELS. *W. Speyer, Sam Tour & Co., New York, N. Y., 1949. PB 109858, 25 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.* Considers steels which can be used in hand tools.

INVESTIGATION OF THE EFFECT OF FATIGUE ON THE TENSILE PROPERTIES OF COLD ROLLED STEEL BARS. *Dirk Perper, 1949. PB 109763, 54 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.75, photostat $8.75.*

INVESTIGATION OF THE PHENOMENA OF CLEAVAGE TYPE FRACTURES IN LOW ALLOY STRUCTURAL SHIP STEELS. *Gershenow and Hornbower, U. S. Naval Research Laboratory. PB 109501, 19 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm, $1.25, photostat $2.50.* Tests substantiating the supposition that various combinations of temperature and constraint can produce fractures in normally ductile steel by simple tension loading.

POLAROGRAPHIC ANALYSIS OF ALUMINUM IN STEEL. *J. M. Dugan, Rensselaer Polytechnic Inst. PB 109658, 37 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.* A simplified method for the analysis of aluminum in steel when the aluminum is present in amounts of 1% or more.

SOLUBILITY OF IRON IN SODIUM METAL, SODIUM-SODIUM OXIDE AND SODIUM-SODIUM OXIDE-SODIUM HYDROXIDE. *A. D. Bogard, U. S. Naval Research Laboratory, Mar. 1953. NRL R4131, 11 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.50.*

SPECTOGRAPHIC DETERMINATION OF TITANIUM IN STEELS. *A. Weissler, U. S. Naval Research Laboratory. NRL M 2436, 36 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash.*

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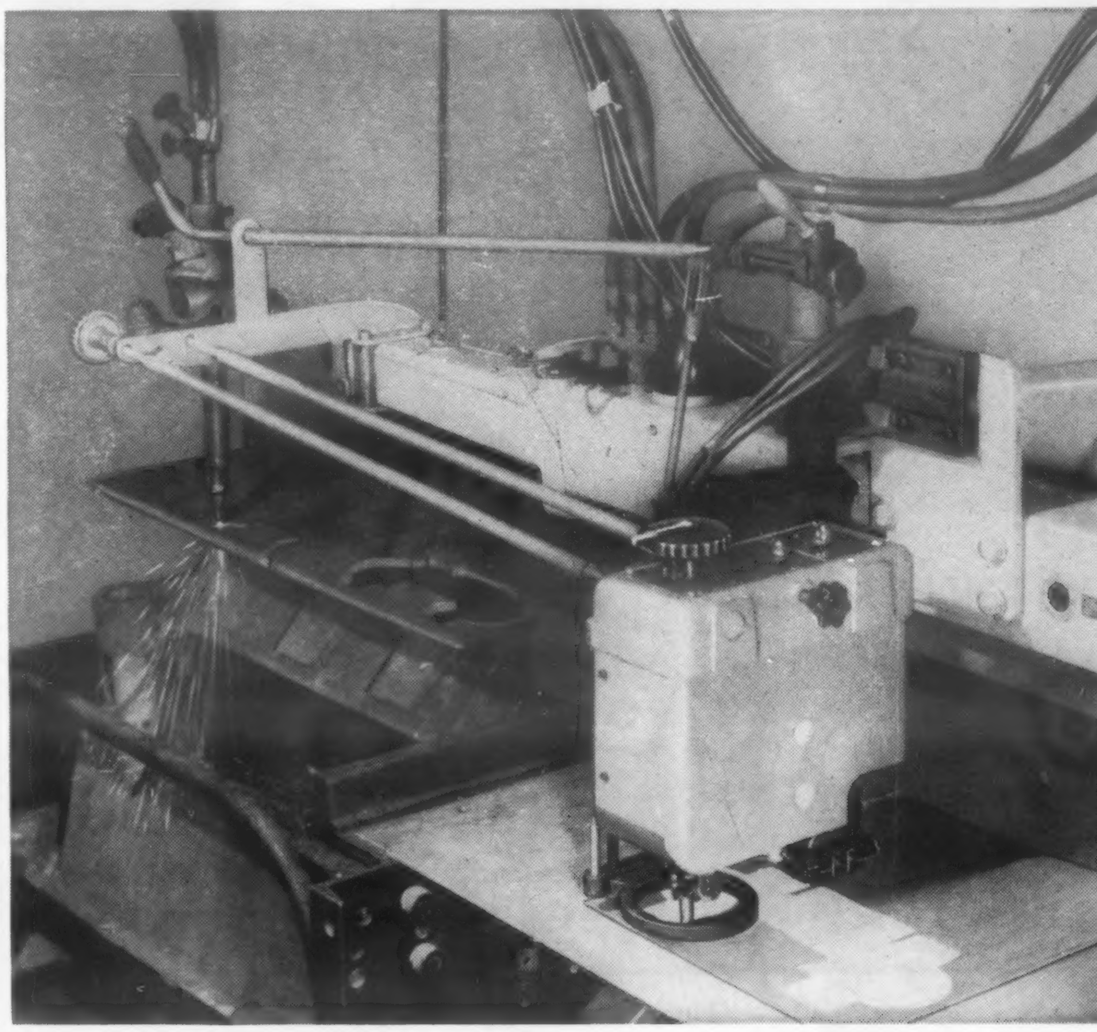

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25, D. C. $1.00. Improved methods for hydrogen peroxide spectrographic determination of titanium in steel and steel alloys involving no separation or bleaching with hydrofluoric acid.

STRESS RELIEF OF GRAY CAST IRON. *J. H. Shaum, U. S. Naval Research Laboratory. PB 109572. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.* Limited supply available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.75. Rate of stress relief at various temperatures, and initial stress and alloy composition effect on stress relief.

STRUCTURAL EFFICIENCIES OF VARIOUS ALUMINUM, TITANIUM, AND STEEL ALLOYS AT ELEVATED TEMPERATURES. *Heimerl and Hughes, Langley Experimental Laboratory, July, 1953. NACA TN 2975, 16 pp. Available from the National Advisory Committee for Aeronautics, Wash., D. C.* Strength under uniaxial compression, elastic stiffness, column buckling and buckling of long plates in compression or shear based on preliminary results of short time elevated temperature compressive stress strain tests of 2 high strength aluminum, 2 titanium and 3 steel alloys.

Parts and Forms

EFFECT OF MEAN STRESS ON THE FATIGUE STRENGTH OF DTD 364 ROUND BARS WITH AND WITHOUT TRANSVERSE HOLES. *G. M. Norris, Great Britain Ministry of Supply, Aeronautical Research Council, 15 pp. Available from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y. $.65.*

FABRICATION OF A TITANIUM ENGINE SHROUD F 84E AIRPLANE. *N. Grossman, Republic Aviation Corp., Aug. 1951. PB 109770, 48 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, photostat $6.25.* Titanium shroud was 31% lighter than comparable stainless steel shroud. Results show present stainless steel fabrication practice cannot be extended to titanium in high volume production. Drop hammering to be used in place of bead rolling.

FINE POWDER PERMANENT MAGNETS, FIRST ANNUAL REPORT. *N. Ananthanarayanan, Lehigh Univ., Jan. 1953. PB 109910, 54 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.75, photostat $7.50.*

Nonferrous

REPORT OF THE TIN RESEARCH INSTITUTE FOR 1952. *Tin Research Institute, Greenford, Middlesex, England, 16 pp. Copies available from Tin Research Institute, 492 W. 6th Ave., Columbus 1, Ohio.* Summary of 1952 research activities of the Institute.

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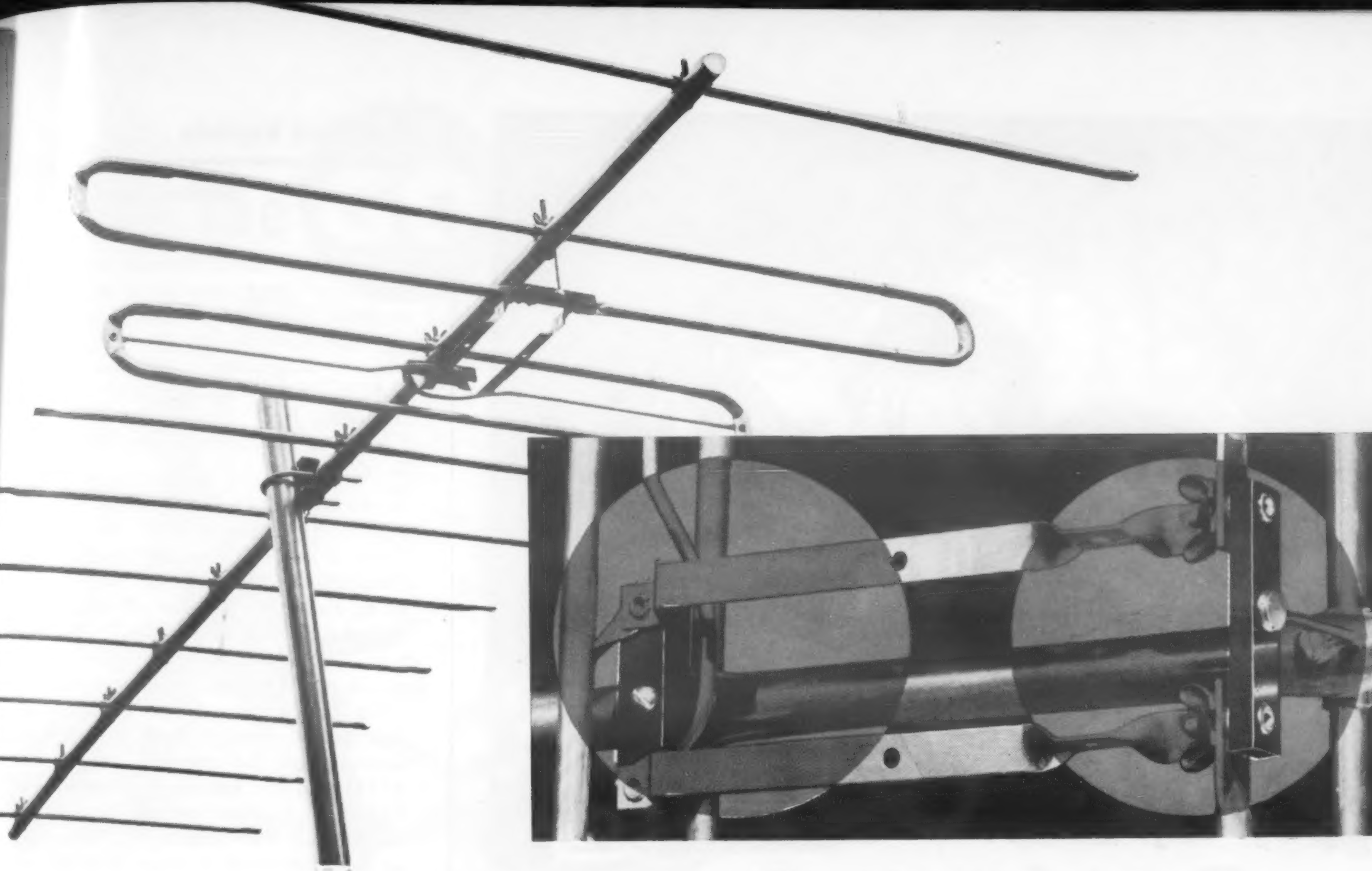

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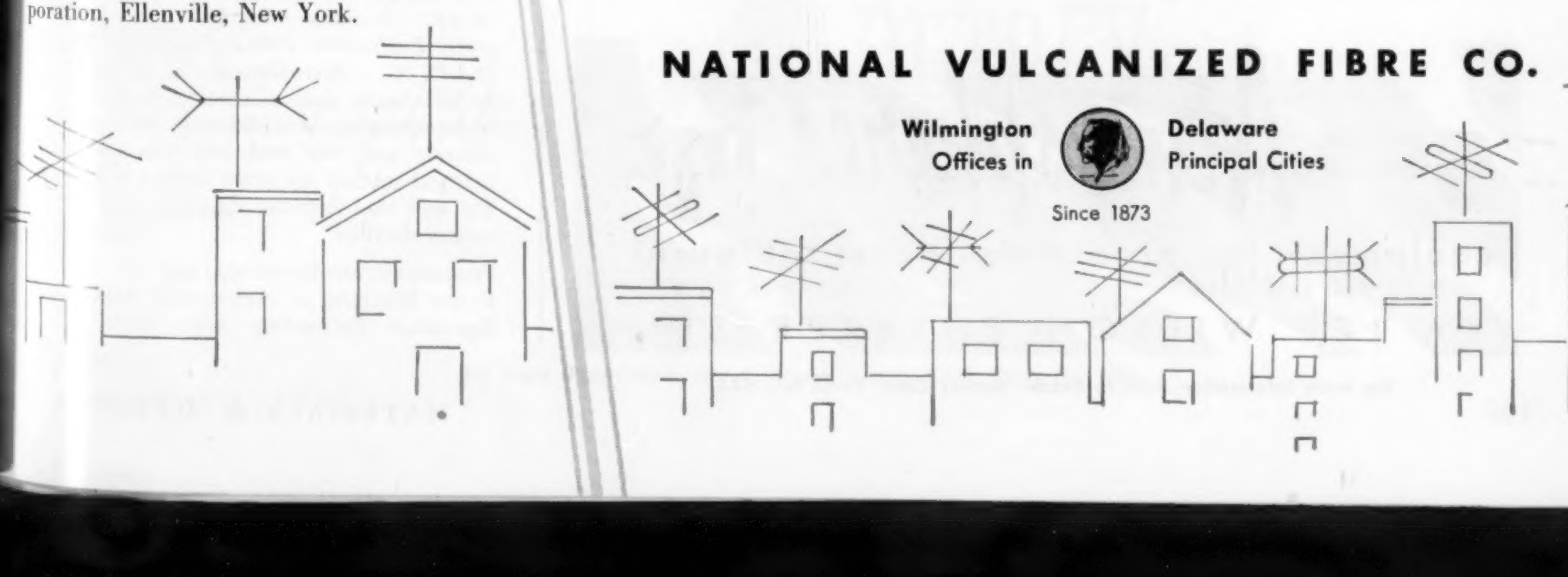

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TO CONTACT AREA DURING THE EARLY STAGES OF FRETTING. I. GLASS, COPPER OR STEEL AGAINST COPPER. *Douglas Godfrey and John Bailey, Lewis Flight Propulsion Laboratory, Cleveland, Ohio. NACA TN 3011, Sept. 1953, 23 pp. Available from the National Advisory Committee for Aeronautics, Wash. 25, D. C.*

STANDARD X-RAY DIFFRACTION POWDER PATTERNS, CIRCULAR 539 VOL. I. *H. Swanson and E. Tatge, 95 pp, $.45,* AND CIRCULAR 539 VOL. II, *H. Swanson and R. K. Fuyat, 65 pp, $.45. Publication of National Bureau of Standards. Available from Government Printing Office, Wash. 25, D. C.* The two volumes present recently made patterns for 84 inorganic substances and compare them with patterns recommended for standard adoption by ASTM and the literature. Patterns were made with a geiger counter spectrometer and for each NBS pattern the three strongest lines are given. Lattice constants and density were calculated and where possible, indices of refraction were measured.

CAUSES OF POROSITY AND LEAKAGE IN NONFERROUS CASTINGS. *U. S. Naval Research Laboratory. Three separate reports.* I. PROGRESS REPORT, *Feb. 1944 to Sept. 1944. Robertson, Fox and Hardy. PB 109518, 20 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50. A limited supply available from Office of Technical Services, U. S. Dept. of Commerce. Wash. 25, D. C. $.50. NRL M 2397.* Aluminum silicon copper alloy castings for air ram cylinders. Foundry procedures and hydrostatic testing.
II. DISTRIBUTION OF MECHANICAL PROPERTIES IN SAND CAST BRONZES. *Brouk and Hardy. PB 109534, 23 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.*
III. THE EFFECTS OF NICKEL, ZINC AND LEAD ON THE MECHANICAL PROPERTIES OF NICKEL-TIN BRONZE CONTAINING 5% TIN. *Fox, Brouk and Loring. PB 109444, 23 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.*

EFFECT OF BORON TRICHLORIDE GAS, TIN, LEAD, AND IRON ON THE GRAIN SIZE AND MECHANICAL PROPERTIES OF MANGANESE BRONZE. *W. Richmond, U. S. Naval Research Laboratory. PB 109519, 16 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50.* Grain size of manganese bronze is decreased by the addition of boron trichloride gas, tin, lead and iron. Most practical method for grain control is iron. Tin and lead decrease ductility, iron increases ductility.

FUNDAMENTAL INVESTIGATION OF THE FLASH WELDING OF ALUMINUM ALLOYS. *Rensselaer Polytechnic Inst., Dept. of*

For more information, turn to Reader Service Card, Circle No. 482

Technical Reports . . .

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Metallurgical Engineering, Troy, N. Y. Hess, Curran, Patriarca, 1948. PB 109819, 114 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $4.75, photostat $15.00. Temperature distribution fundamentals and effect of various variables on flash welding aluminum alloys.

INVESTIGATION OF ALTERNATES FOR TIN FOR METALLIC COATINGS FOR RADIO HOOK-UP WIRES. *J. B. Russell, U. S. Naval Research Laboratory. PB 109528, 53 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.75, photostat $7.50.*

STUDIES AND EXPERIMENTAL INVESTIGATIONS FOR THE DEVELOPMENT OF PHASE DIAGRAMS OF THE TITANIUM- AND CHROMIUM AND TITANIUM-COPPER ALLOY SYSTEMS. *Massachusetts Inst. of Technology, Dept. of Metallurgy. Order separate parts described below from Library of Congress, Publication Board Project, Wah. 25, D. C.* PART I. *Cuff, Joukainen, Richardson, Nicholls. PB 109702, 55 pp. Microfilm $3.00, photostat $8.75.* Partially complete titanium chromium binary system in the range from 0 to 65% chromium. Preliminary diagram of copper titanium systems from x-ray and metallographic examinations. PART II. TITANIUM COPPER AND THE TITANIUM CHROMIUM PHASE DIAGRAMS. *Cuff and Joukainen. PB 109703, 47 pp. Microfilm $2.50, photostat $6.25.*

SYSTEM FOR CONTROLLING THE SPEED OF AN ALUMINUM EXTRUSION. *S. Kahn, Rensselaer Polytechnic Inst. PB 109818, 82 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.75, photostat $8.75.* Laboratory analog of industrial process and conversion from analog to industrial application.

Nonmetallics

EXPANDED, MONO-CELLULAR POLYVINYL CHLORIDE. *D. S. Grief, U. S. Chemical Corps, Chemical and Radiological Laboratory, Army Chemical Center, Md., 1953. PB 109771, 6 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.25, photostat $1.25.*

FRICTIONAL BEHAVIOR OF POLYETHYLENE, AND HALOGENATED DERIVATIVES. *Bowers, Clinton, Zisman, U. S. Naval Research Laboratory, May 1953. NRL R 4167, 23 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.75.* Investigation of static and kinetic frictional properties of a group of unplasticized linear high polymers and copolymers. Friction measurements on a Bowden Lleben "stick slip" machine were made for steel sliding on polymer, polymer on polymer and polymer on steel with both types of polymer.

DETERMINATION OF PROGRESSIVE CORROSION OF GLASS TANK REFRACTORIES.

For more information, turn to Reader Service Card, Circle No. 476

Technical Reports . . .

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Herold and Maheshawary. Missouri Univ. School of Mines and Metallurgy, Dec. 1952, Report No. 82, 30 pp. Available from Univ. of Missouri School of Mines and Metallurgy, Rolla, Mo.

MECHANICAL PROPERTY TESTS ON CERAMIC BODIES. *Battelle Memorial Inst., Columbus, Ohio, 1950 Progress Report on Air Force Contact. PB 109762, 8 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.25, photostat $1.25.* Research progress directed toward increasing knowledge of the load bearing characteristics of Ceramic Bodies.

Nonmetallics

COLOURATION OF SOME OPTICAL GLASSES BY X AND GAMMA RADIATION. AN A. E. R. E. REPORT. *J. V. F. Best, Great Britain Ministry of Supply, Atomic Energy Research Establishment, Mar. 1953. Report AERE C/R 1125, 19 pp. Available from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y. $.75.*

RUBBER COMPOUNDS USED IN SHOCK MOUNTING, DEVELOPMENT OF. *Thurman, Rice, Taylor. U. S. Naval Research Laboratory. PB 109532, 14 pp. Available from Library of Congress, Publication Board Project, Wash. D. C. Microfilm $1.75, photostat $2.50.*

Joining

DETERMINATION OF THE OPTIMUM CONDITIONS FOR THE SEAM WELDING OF 0.031 IN. MONEL SHEET. *G. M. Slaughter, Rensselaer Polytechnic Inst., 1949. PB 109657, 23 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.* Variables of electrode force, timing cycle, wheel speed, welding current, and surface treatment isolated and analyzed.

WELDABILITY OF CAST CHROMIUM MOLYBDENUM STEELS FOR SERVICE IN STEAM LINES AT 950 F. *Pugacz and Rinebolt, U. S. Naval Research Laboratory, 1949. NRL M3474, 24 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.75.* Preheat and postheat temperature requirements for weldability and ductility.

WELDABILITY TESTS OF HIGH TENSILE STEEL (BU SHIPS WELDING TESTS NO. 324 AND NO. 325). *Partial Report from U. S. Naval Research Laboratory. PB 109507, 45 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, photostat $6.25.* Comparison of relative weldability of nine manganese-titanium steels, a manganese vanadium steel, a mild steel.

Coatings

ELECTRODEPOSITION OF CHROMIUM ALLOYS. *A. Taboada, 1952. PB 109859, 36 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.*

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GALVANIC CORROSION THEORY FOR ADHERENCE OF PORCELAIN ENAMEL GROUND COATS TO STEEL. *D. G. Moore, J. W. Pitts, J. C. Richmond, W. N. Harrison, U. S. National Advisory Commission for Aeronautics, June 1953. NACA TN 2935, 19 pp. Available from National Advisory Committee for Aeronautics, 1724 F St., Wash. 25, D. C.*

RECOUVREMENT PAR VOIE ELECTROLYTIQUE DU FER PAR LE TITANE (TITANIUM ELECTROPLATING OF IRON) SECOND PART. *PB 109652, 14 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50. Translated from the French original by Armed Services Technical Information Agency Document Service Center. Declassified Oct. 1952.*

UEBER DIE HARTE VON HARTCHROMSCHICHTEN (ON THE HARDNESS OF HARD CHROME COATINGS). *H. Aren, 1953. PB 109732, 16 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50. Translated and edited by F. A. Raven from Metalloberflache, ausgabe B, Vol. 3 No. 5, 1951.*

Miscellany

METALS CUTTING AND TOOL TEMPERATURES. *Carman, 1948, Rensselaer Polytechnic Inst. PB 109828, 90 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.75, photostat $11.25.* A review and correlation of available information on subject of metal cutting and tool life, compared with data gathered by a new testing apparatus and method for reading cutting temperatures at the tool work interface.

BRITISH PRESSED METAL INDUSTRY: REPORT OF A PRODUCTIVITY TEAM FROM THE USA WHICH VISITED THE UNITED KINGDOM IN 1951. *Anglo-American Council on Productivity, 1953, 50 pp. Available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C. $.75.*

TITANIUM NITRIDE CERMETS. *Davey, Glabao, Lorey, New Jersey Ceramic Research Station, Rutgers Univ., New Brunswick, N. J., 1952. PB 109701, 33 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.* Several compositions of cermets based on titanium nitride investigated for strength in cross bending, oxidation and thermal shock resistance. Effect of processing techniques evaluated. Titanium nitride cermets containing chromium found to have best properties.

INTERPRETATION OF NOTCHED-BAR IMPACT TEST. *C. E. Jackson, M. A. Pugacz and F. S. McKenna, U. S. Naval Research Laboratory, Nov. 1943. Report PB109331, 30 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.* Effects of testing temperature, notch dimension, test speed.

News Digest

Powder Metal . . . .

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powder metals in Europe today. Some of the highlights . . .

Germany: H. H. Silbereisen said that his country used over 3000 tons of iron powder per month during the war, but is now using only 60 to 100 tons per month, about 80% of which goes into machine parts; the balance is used by the chemical industry and for electrode production. Germany is at present the second largest producer of powdered metal in Europe, turning out about 500 tons per month, of which about 4/5 is exported. He said the development of ductile alloy powders from molten state held great promise for the industry. Commercial production of thin strip from powdered metal rolled between hot rollers and immediately sintered has met with success in Germany, and progress has been made in producing composite strip (such as copper on one side, iron on the other) by that method. Easton Metal Powder Co. reportedly uses the process in the U.S.

England: C. J. Leadbeater of the British Ministry of Supply said he had no figures on production, but one or two firms in England were producing ferrous and nonferrous powders commercially. He felt that progress in England was quite slow, particularly in ferrous parts, due to the conservatism of British management. The Ministry of Supply is anxious to promote the use of metal powder, because of its material economy, but last year efforts to form a metal powder association in England failed due to lack of interest. The Ministry of Supply is sponsoring research work in the universities.

British progress in the field of electronic powder metal application is more advanced, particularly in the field of ferrites and fine iron powders for permanent magnets. W. T. Dean of the Mullard Blackborn Works reported that barium ferrites were now in production at the rate of 1000 to 1500 tons annually. Magnets of barium ferrites have been produced experimentally with a BH-max of 4,000,000 and are expected to reach 3,000,000 BH-max commercially. A problem, he reported, was obtaining oriented grains on a commercial scale. He did not expect to see ferrites replace the alnicos except in extremely small sizes because casting large sizes

would always be less expensive.

The European visitors expressed a particular desire to see American production techniques in action, and the itinerary planned for them insured they would be exposed to a great deal of it before they return to sail for Europe on Nov. 7. The powder experts visited plants in New York, New Jersey area, Philadelphia, Detroit, Chicago, Columbus and Cleveland.

Typical of the production ideas that the visitors picked up on their trip is American Electro Metal's method for eliminating erosion during the impregnation of porous powder metal parts. The company developed a simple, reuseable porous metal "bridge" to feed a copper-molybdenum impregnating alloy to jet engine blades pressed from powder metal. The bridge absorbs the erosion caused by the melting alloy, yet is easily knocked off the finished part after heat treatment.

The information and experience that this trip offers to the visiting European scientists might well be envied by American powder metallurgists. Much of it will be available in reports that the OEEC will compile after the project is completed.

MPA Reviews Outlook for Metal Powder Products

A rapidly growing Metal Powder Association held its first Fall Meeting, September 11 and 12 at White Sulphur Springs, West Virginia, and there reviewed the outlook for metal powders and metal powder products. All in all, the reports presented indicate that the industry is healthy and that use of metal powder parts in both military and civilian products continues to increase.

The outlook for metal powder parts in various applications was discussed by a panel under the chairmanship of Robert Talmadge, Consultant. Mr. Talmadge predicted that it will not be long before the price of steel powder will be less than that of finished

News Digest

steel and may approach that of pig iron. "The cost per pound of production decreases as the size of the plant increases and," said Mr. Talmadge, "today's production plants are still extremely small compared to steel. Furthermore new ways are being found to produce good powder directly from ore and new methods are being found to reduce today's production costs."

Clyde Batchelor, Raybestos Manhattan Corp., Inc., discussed friction materials made from metal powders and pointed out that with the advent of automatic transmissions and more powerful engines the use of this type of clutch and brake material is rapidly becoming essential and should represent an expanding market for metal powders.

The application of metal powder parts in washing machines and other household appliances was reviewed by W. A. Irvine of the Maytag Co., who stated that they are using metal powder bushings, gears and structural iron parts in such equipment because they offer considerable economy and precision as well as characteristics, such as self-lubrication, unique to powder metallurgy.

Concluding the panel discussion, T. L. Robinson, Powdercraft Corp., pointed out that small iron castings, when required in limited quantities, can be very expensive, but that in many cases these are being economically and satisfactorily replaced by metal powder parts, the textile industry providing a typical example. Mr. Robinson went on to provide detailed comparative analyses of several specific examples.

The iron powder outlook was discussed by another panel consisting of chairman, G. H. Tulley, Metals Disintegrating Co., John Dale, Charles Hardy, Inc., B. T. duPont, Plastic Metals Div. of National Radiator Co., and E. C. Kenney, Eckstrand & Tholand, Inc. They reported that there is now ample iron powder capacity to meet present demands and it appears that there will be idle facilities for possibly the next two years. Caution was therefore expressed against overexpansion of iron powder production facilities which could result through false encouragement by the government and other large potential powder consumers, or through non-factual press releases and promotional literature.

The nonferrous powder outlook

For more information, turn to Reader Service Card, Circle No. 336

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was taken up by a panel composed of chairman, E. H. Klein, New Jersey Zinc Sales Co., E. P. Palmer, Glidden Co., G. H. Tulley, Metals Disintegrating Co., and P. E. Weingart, American Metal Co., Ltd. This discussion brought out the fact that at present there is a great demand for new nonferrous powders to meet a variety of special requirements. Particularly evident are the demands for special powders for ordnance items and for filters in such fields as oil refining, chemical processing and diesel engines. The panel predicted that this trend to special nonferrous compositions would continue.

The expanding application of powder metallurgy in ordnance was covered by John D. Dale representing Frankford Arsenal, Philadelphia. "The sintered iron shell rotating band development program is continuing," said Dale. "Along with the improved quality and performance of iron powders and parts made from them, revision to existing specifications are being considered carefully." Mr. Dale reported that since the last review of this topic, more than 2,000,000 artillery shells have been furnished with sintered iron bands for issue to troops in the field. "It will be some time before all the reports are in concerning their performance, accuracy and their effect on the life of the weapon," he said. After some early disappointments, which might be expected in any new development, there has been not a single lot reported to be rejected from any production lots at the proving grounds. The 105 mm shell band has been redesigned down to and including production tools and production method. The first large scale firing test of the new design is scheduled to start this month (Sept.). When the results are known it will be decided to what extent sintered bands can be applied to that round. Excellent progress is being made and useful data should be at hand before the end of the year.

The outlook for electronic iron powder cores was revealed by Henry L. Crowley Co., Inc. of West Orange, N. J. Among the reasons for the continuing extensive use of iron-powder cores are: 1) greater efficiency through increased gain with lower losses, 2) conservation of critical and restricted materials, 3) marked reduction in size and weight of electronic assemblies, due to the higher work-

For more information, turn to Reader Service Card, Circle No. 500

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ing efficiency of iron core coils.

More recently, a new ferrite magnetic material has greatly expanded the application horizon. With many times greater permeability available than that from conventional powdered iron, this new material opens up startling size reduction and weight saving possibilities.

The latest development in the field of permanent magnets as reported by Mr. Crowley and H. Delaney of the Henry L. Crowley Co., Inc., is a ceramic-base permanent magnet material, which is a lightweight, magnetically hard, permanent magnet body containing no critical raw materials, and therefore available for applications entirely divorced from essential classified products. It is produced by powder metallurgy methods and is adaptable to pressing in a wide variety of contours and intricate shapes without need of machining. Further reviewing the electronic core industry, T. L. Moore, General Dyestuff Corp., discussed the powder supply picture for electronic cores.

The first of the two-day session was taken up by meetings of the Powder Producers Div., the Fabricators Div., and the Electronic Core Div. each devoted to specific problems of the individual divisions. The meeting of the Fabricators Div. was of broad significance because it demonstrated the value of equipment manufacturers and parts producers getting together to discuss their common problems. At this meeting, the subject of presses for producing metal powder parts was discussed and the press manufacturers present took away with them much valuable information on the needs and problems of the metal powder parts industry. Because of the success of this session, the Fabricators Div. plans to devote a part of their next fall meeting to sintering problems and equipment. Furnace manufacturers, who are members of MPA, will be invited to participate.

Correction

In File Fact No. 260, "Nominal Compositions of Typical High Strength Heat Resisting Alloys and Limited Stress Rupture Data", page 139, September 1953, the stress-rupture data given for the last two groups of alloys (Intermediate and Other Jet Engine Alloys) were determined at 1200 F instead of 1500 F. A note to this effect should be inserted in the last two columns.

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BDSA . . . .

continued from page 8

Offices and 25 Industry Divisions. The staff offices:

1. The Office of Technical Services, which is the clearing house for government technical data, will also assist industry in voluntary product standardization and in regional and local area development. The OTS includes Area Development, Commodity Standards, and Trade Association Divisions.

2. The Office of Small Business is the focal point for liaison with the Small Business Administration.

3. The Office of Distribution, which is the center for retail, wholesale and distributive trades, will centralize information on marketing and distribution programs and policies.

Industry Divisions

The 25 Industry Divisions are designed to meet the needs of specific areas of industry in regard to defense production activities, mobilization preparedness and government services that can be rendered in the interest of efficiency and economic stability. Each division will be headed by a division director, and the majority of division directors will be recruited from the ranks of industry to serve as WOC's (without compensation) on a six month rotating basis. Supporting staffs, deputy division directors and government industry specialists will be supplied through civil service channels.

The most important specific functions of the Industry Divisions of the BDSA fall under the three main categories of defense, preparedness and service to business.

Defense functions will be: administration of the Defense Materials System and provision for recommendations to the Office of Defense Mobilization on expansion goals, tax amortization and domestic loans.

Mobilization activities include: participation in development of a Government base program for industrial facilities in event of national emergency; collection of information for rating facilities to be protected against enemy attack; provision of assistance to the ODM for wartime industrial reorganziation.

Business services function as an official type of "lobby" providing in-

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formation and advice to congress through administration officials with the objective of promoting industrial expansion and business progress. They will: collect, analyse and distribute information on business activity to trade groups, industry and government agencies; evaluate policies and orders of the Department of Commerce as they are reflected in business climate and operation; assess the impact of government operations insofar as they impinge on the interests of private business; and assist domestic business in its relations with other departments and agencies of the government.

In somewhat simpler terms, the industry groups will offer at least a starting point for members of specific industries who want to be heard in Washington, or who want information or action from the government relating to their business or technical field.

The Industry Divisions of the BDSA are as follows:

1. Agricultural, Construction and Mining Equipment
2. Aluminum and Magnesium
3. Automotive
4. Building Materials and Construction
5. Business Machines and Office Equipment
6. Chemical and Rubber
7. Communications Equipment
8. Consumer Durable Goods
9. Containers and Packaging
10. Copper
11. Electrical Equipment
12. Electronics
13. Food Industries
14. Forest Products
15. General Components
16. General Industrial Equipment
17. Iron and Steel
18. Leather Shoes and Allied Products
19. Metalworking Equipment
20. Miscellaneous Metals and Minerals
21. Power Equipment
22. Scientific, Motion Picture and Photographic Products
23. Shipbuilding, Ordnance, Railroad and Aircraft
24. Textiles and Clothing
25. Water and Sewage Industries and Utilities.

(More News on page 220)

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Accordian pleats in the side of rammed ship offered engineers an opportunity to examine the behavior of welded seams under extreme stress.

Damage in Ship Collision Reveals Weld Strength

Ramming an oil tanker into the port side of a 7500 ton freighter is hardly an ASTM-approved method for testing the behavior of welded seams in ship construction, but it does offer a chance to see what happens to materials and workmanship under conditions of unusual stress. Engineers, studying the damage sustained by the SS Loide Panama when she was rammed in a fog off the New Jersey coast, claim that the welded seams in the damaged area provide convincing evidence of the desirability of welded over riveted hull construction.

Examination of the 25-ft deep puncture in the side of the Loide Panama revealed that the 7/8-in. welded plates fractured without relation to the welded joints. Where the deck plating and hull plates had been virtually accordion-pleated by the force of the collision, the weld seams followed the 180 deg bends with no signs of fracture. Examining engineers felt that the damage to the ship was much more localized, considering the tremendous impact of the collision, than might have been expected from a similar riveted hull.

(More News on page 222)

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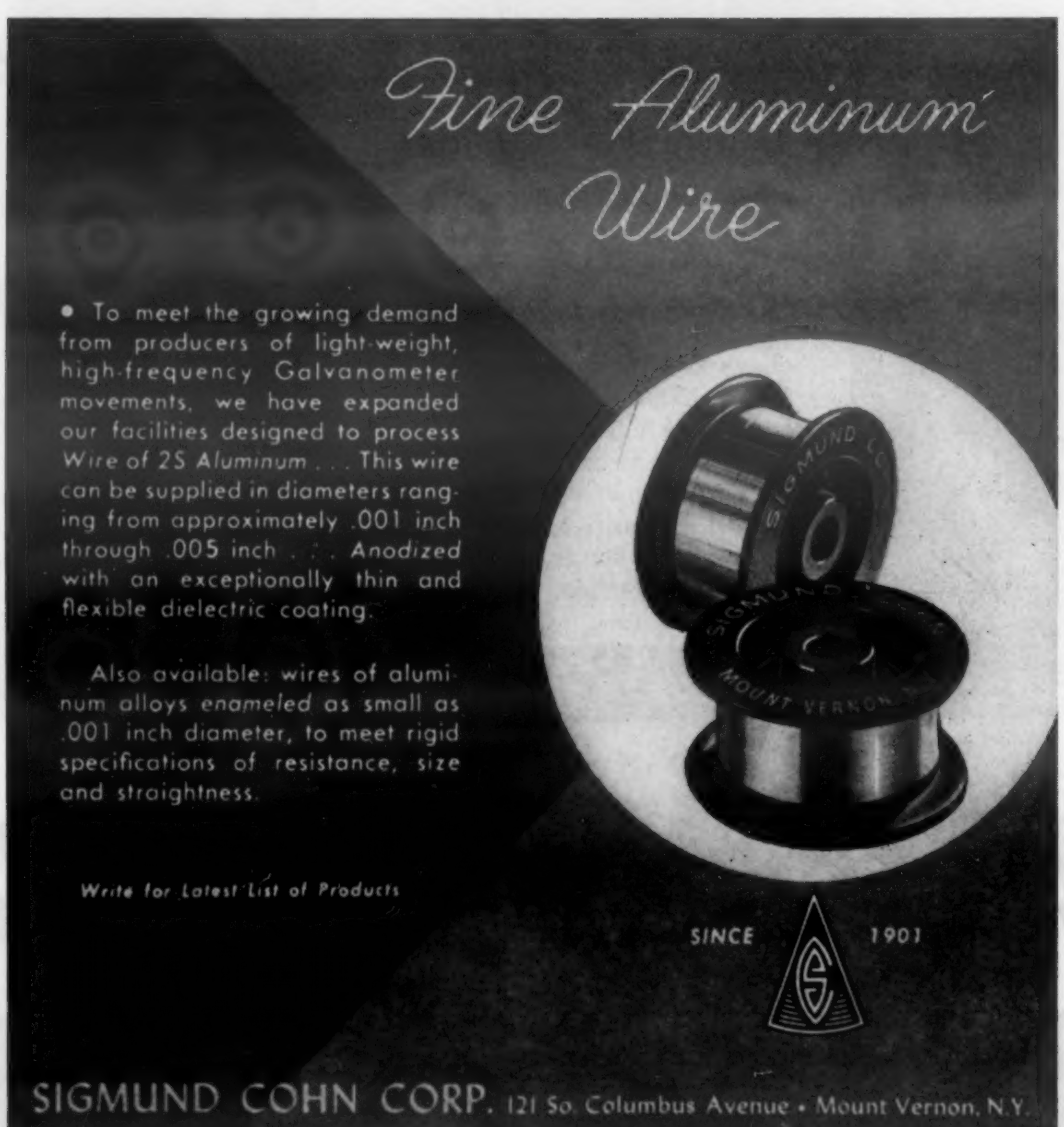

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Gov't. Removes Nickel Controls

The Business And Defense Services Administration decontrolled nickel effective Nov. 1, 1953. While the action frees manufacturers and users of nickel from all distribution and end use restrictions, the action at this time may be a mixed blessing in many cases. As reported last month, nickel is almost critically short and releasing control on its use will have little effect in increasing the supply available to most producers. There is not enough nickel in sight, either this year or next, to provide for defense, stockpile and all civilian uses, particularly in the chromium-plate world of consumer goods.

Secretary of Commerce Weeks claimed, "Decontrol of nickel will be a boon to thousands of small business firms, especially fabricators and electroplaters. For two years small businessmen have complained that government restrictions on nickel were causing them to lose business. We have been working on the problem . . . making sure defense requirements could be met so small business could get its long needed break." However, he added: "Revoking the control order does not in itself indicate an increase in the overall supply of nickel for non-military uses . . . it does mean that hereinafter producers . . . can use without restriction the metal they purchase in a free market for making goods they expect the public to buy."

The government order for freeing nickel is almost entirely across the board. BDSA revoked the entire order M-80 with the exception of the part relating to columbium and tantalum, strategic metals which will remain under allocation and end-use control. The revocation removes all restrictions on the use of nickel, nickel silver and nickel bearing stainless steel. It also relieves industry of the burden of filing National Production Authority forms relative to the use of nickel and nickel bearing alloys.

Adequate provision has been made to ensure that all nickel requirements of the military services and the AEC will be safeguarded by the defense materials system. Stockpile requirements will continue to be filled by procurement contracts. Both military

and stockpile needs will, of course, have priority over civilian uses, so the net effect of the order is to free whatever nickel is left over after strategic requirements are filled to the distributive discretion of free market competition. Undoubtedly, this will permit some fabricators to use nickel in instances previously forbidden, but the net effect may put a serious pinch on some manufacturers and fabricators who have been using nickel in large quantities under regulations which exist now.

The nickel decontrol move by the Business and Defense Services Administration is the first step in the Defense Materials System by the new Commerce Dept. agency as reorganized on Oct. 1. The new agency plans to continue the defense and mobilization functions which have been left over from the abolished National Production Authority.

Stapled Aluminum Tested By N.B.S.

High strength aluminum sheet can be stapled with galvanized steel wire and still maintain a high degree of corrosion resistance to marine atmosphere, according to tests recently completed by the Bureau of Standards.

The speed and economy of galvanized-wire-stitching for joining aluminum sheet has resulted in new and more widespread uses. Originally used for joining non-load bearing partitions in aircraft, stitching proved practical and economical in applications such as motor bus interior panels and insulated wall panels in the building field.

In corrosion tests, stapled sheets of 24S-T3 high strength aluminum-copper-magnesium alloy and alclad 24S-T3 showed satisfactory corrosion resistance for service in marine atmospheres. However, only the alclad alloy showed sufficient corrosion resistance for service use involving frequent wetting by sea water. The plain alloy deteriorated quite rapidly in tidewater exposure tests.

Tests were conducted by the NBS over a 37 month period. Stapled panels were exposed to marine atmosphere and tidewater with periodic observations after 6, 11, 22, and 37 months.

(Continued on page 226)

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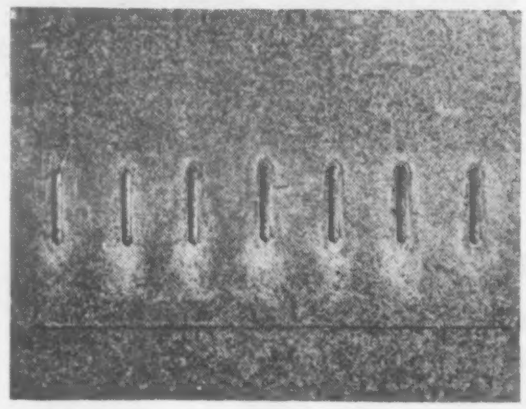


Aluminum alloy sheets stapled with zinc coated steel wire show satisfactory corrosion resistance after 37 month exposure to marine atmosphere. Illustration shows condition of staples and sheet after test.

When exposed to marine atmosphere only, neither the clad nor unclad alloys showed much evidence of corrosion attack during the entire 37 month period. Staples on both materials maintained a coating of grey corrosion products, indicating that zinc or zinc iron layers were still present. None of the staples were significantly pitted, and while some evidence of pitting showed up between the joined surfaces of the unclad material, no intergranular or stress corrosion was found. In the case of the alclad sheets, minor pitting occurred only slightly in some areas of the joining surfaces, but in no case had pitting progressed to even half the thickness of the clad layer. Crevice corrosion was very mild, and only insignificant amounts of corrosion products were found between the joint surfaces of the unclad panels.

On exposure to tidewater (intermittent immersion) the unclad panels deteriorated rapidly. Within 6 months the zinc coating was completely removed from the staples by sea water and by the end of the 37 month period the area of the staples was severely corroded and cracked.

The alclad panels, on the other hand, resisted attack to a much greater extent. The corrosive attack on the zinc coatings of the staples was much less severe and at the end of the testing period some of the zinc-iron alloying layers were still present and the underlying steel had barely begun to pit. The interfaces of the panels showed little evidence of crevice corrosion and no attack on the

"YOUR COST PER FINISHED ARTICLE IS THE *TRUE* COST OF YOUR CLEANER"

The case of the "SPOTTED BUMPERS"

Gloom had settled over the "Super's" office. Inspection was rejecting bumper after bumper because of tiny defects marring its gleaming finish.

To make matters worse—ALL the usual test methods failed to disclose the cause of the rejects.

Finally — Northwest was called. A "Cleaning Specialist" rushed to the scene. His methodical check of the cleaning and plating operations revealed nothing amiss.

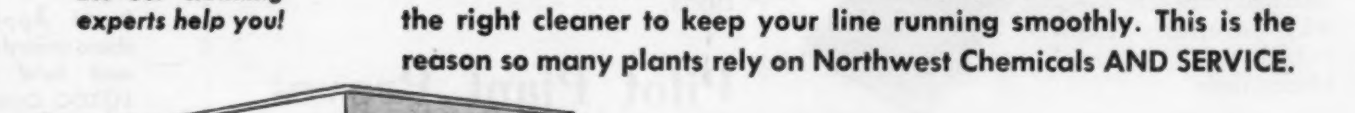
Retracing his steps, the Northwest "Cleaning Specialist" found "HER". A cute blond—busily racking bumpers—with lovely hands encased in gloves held together with liberal strips of zinc oxide tape.

Here was the culprit. Her taped gloves left invisible traces of rubber-like adhesive on the parts after they had been cleaned. A new pair of gloves and production returned to normal.

This little episode illustrates our point that Northwest's "Cleaning Specialists" are not only cleaning experts in a technical sense, but practical production engineers as well.

Any one can give you a cleaning compound that will do a job of sorts, but a Northwest "Cleaning Specialist" will give you the right cleaner to keep your line running smoothly. This is the reason so many plants rely on Northwest Chemicals AND SERVICE.

Got a problem? Let our cleaning experts help you!



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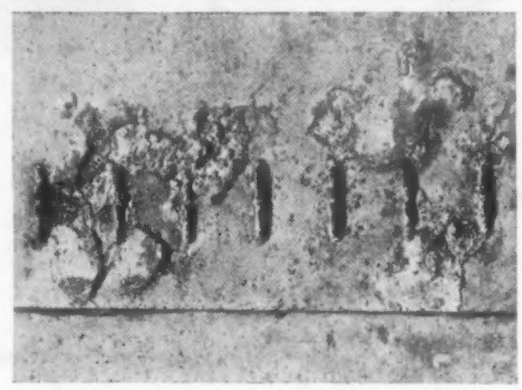
core material at 22 months. At 37 months the core showed some pitting and in isolated instances evidence of stress corrosion.



After 37 month exposure to intermittent immersion in sea water, the alclad stapled joint (top) is still secure while the unclad joint (below) has deteriorated beyond use.

While corrosion resistance to marine atmosphere is satisfactory in both clad and unclad stapled sheet, evidence of some degree of crevice corrosion at the joining faces of the sheets indicated that even longer life for the joint is possible if a protective coating is applied to the joining area of the sheets. A non absorbing type of sealing compound or paint applied to the joints either during or after the joining operation will result not only in maximum service life, but also in a leakproof seal, which is often required in aluminum sheet applications.

Pilot Plant Proves Continuous Casting

Four years of pilot plant operation of a continuous steel casting system has proved that the process is commercially practical, according to Allegheny Ludlum Steel Corp. The corporation announced that plans are now underway to build a continuous casting plant on a commercial scale as a result of experience gained in the pilot stage.

The new continuous casting plant

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will pour billets, slabs and rounds directly from molten metal, eliminating ingot, soaking pit, and blooming mill operations required in standard steel production operations.

W. B. Pierce, vice president and technical director of Allegheny Ludlum, revealed his company's plans for the continuous machine in a paper delivered before the Regional Meeting of the Iron and Steel Institute. He said the new plant under consideration has a mold cross-section of approximately 150 sq in. and is designed for a casting speed of about 120 in. per min. At that rate the unit would produce at least 20 tons per hour as a single unit. He added that it was entirely logical to make a multisection unit casting several billets simultaneously, with corresponding increments in the casting rate of the system.

The pilot plant was installed in April 1949. It is basically a Rossi-Junghans machine similar to continuous casting installations in the brass industry. It utilizes the Junghans principle of the oscillating mold, in which the mold travels with the bar for a short movement, then snaps back to its original position, giving a stripping action to free the hardening melt from the side of the mold. The mold itself is copper—water cooled and chrome plated where it contacts the hot metal. Billets and rounds of most common alloy steels up to 15 x 3 in. were produced consistently in high quality during operation of the pilot plant.

The mold is supplied with hot metal from an induction furnace at the top of the pouring tower. In the commercial installation the furnace would be replaced by a heated ladel to prolong operation between repair cycles.

Below the mold, water spray rings cool the emerging billet and it is cut to length by oxyacytelene torches.

Economics of Process

Experience to date indicates that casting from the machine will be more expensive than casting ingots, but important economies will result from increased yield, which has been up to 10% greater than the yield obtained from conventional hot topped ingots. In installations where no blooming mills are in existence, the capital cost of the continuous machine would be much less than a comparable melting-casting-blooming operation.

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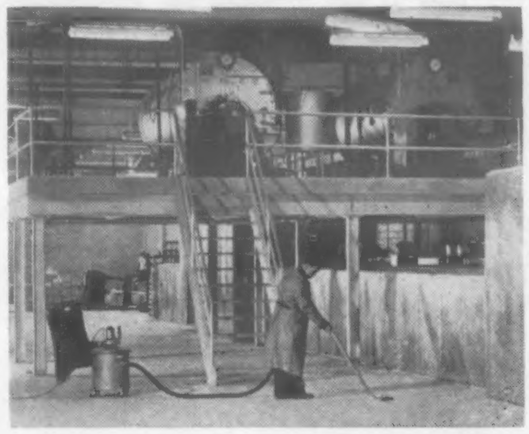


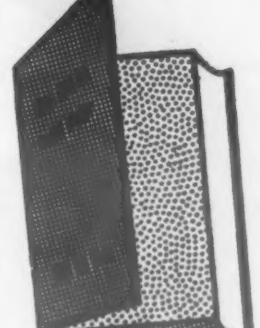
Vacuum cleaning every 24 hr keeps plant floors laboratory-clean in new welding electrode plant.

New Electrode Plant Keynotes Cleanliness

A new welding electrode plant recently completed is virtually hermetically sealed against contamination by dust and dirt. The plant, built in Lancaster, Pa., by the A. O. Smith Co. represents a million dollar effort to provide optimum conditions for mass production of metal welding rods. The company reports that while it is not difficult to turn out almost perfectly uniform rods in laboratory batches, many difficulties are encountered at extrusion rates of 20 rods per second and up. By avoiding contamination by dust and dirt and careful control of raw materials, the company believes that laboratory quality can be attained in large batch production.

The plant incorporates nearly every method for eliminating dust and dirt. It is windowless, and completely air conditioned by a system that keeps inside pressure slightly above outside pressure in order to force dirt out through doors and small openings. The plant is built with all interior surfaces accessible for cleaning. Walls and vertical surfaces are of smooth, dirt resisting materials such as vitreous tile. Every foot of floor space is vacuumed cleaned at least once every 24 hr to rid the plant of any material that is spilled or tracked in by employees.

The cost of the cleaning operations and excessive care in construction is expected to be offset by longer extrusion die life, fewer rejects and more efficient production scheduling.



BOOK REVIEWS

Weldability

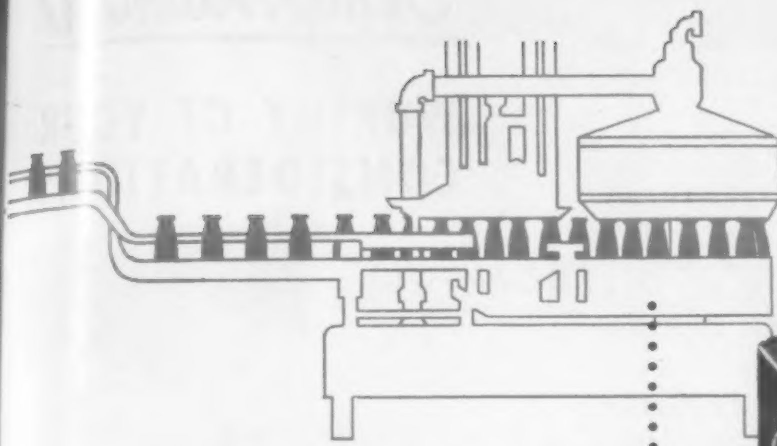
WELDABILITY OF STEELS. *By Robert D. Stout and W. D'Orville Doty. Published by Welding Research Council, New York, N. Y., 1953. Cloth, 6 by 9 in. 381 pp. Price $6.50.*

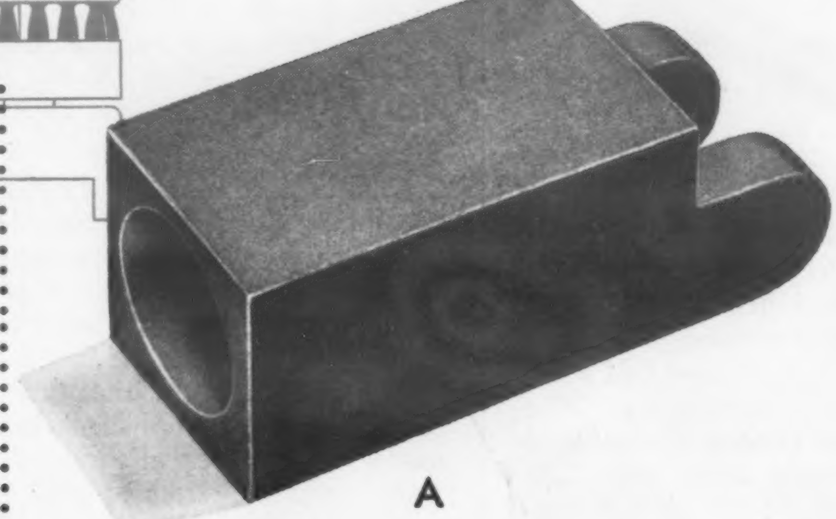
This book was prepared under the auspices of the Weldability Committee of the Welding Research Council to digest and correlate the information which has been published during the past fifteen years on the weldability of carbon and low alloy steels.

The monograph is divided into thirteen chapters. Since it is impossible to discuss weldability without reference to welding processes and metallurgy, the early chapters cover the fundamentals of these subjects briefly. Other chapters deal with the basic factors which influence the weldability of carbon and low-alloy steels and suggested methods for welding the commonly used steels. The remaining chapters contain a review and critical evaluation of weldability tests and general conclusions on the present state of our knowledge of weldability.

Probably the most widely useful part of the book is an Appendix consisting of 50 pages of tables wherein all of the standard specification steels, such as ASTM, SAE, ABS and others, are classified into three categories, those which are readily weldable, those in which some precautions are needed and, finally those which require special precautions and considerations. Exact welding procedures are indicated for each thickness of steel. These procedures tend to be a bit conservative but are based on the best knowledge available to date.

The book is well documented, containing 200 references to the literature on welding. It should be read





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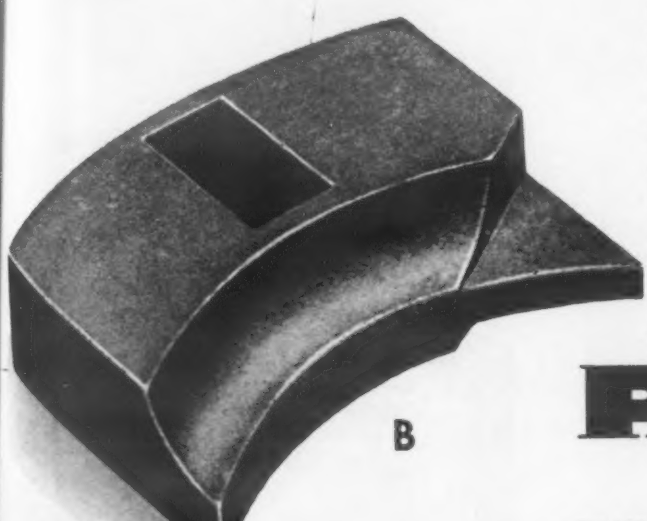

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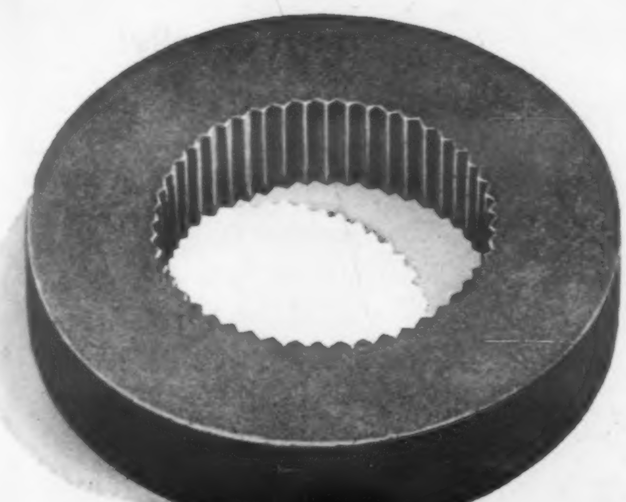

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Book Reviews

(continued)

by all engineers who are faced with the problem of welding steels.

Refractory Hard Metals

REFRACTORY HARD METALS. *By. Dr. Paul Schwarzkopf and Dr. Richard Kieffer. Published by The Macmillan Co., New York 17, N. Y., 1953. Cloth, 6 by 9 in. 447 pp. Price $10.00.*

This book, the first in English on this branch of powder metallurgy, provides an up-to-date presentation of the history, present status of the art, and current trends in development in this field. It is based on a critical review of the literature supplemented by unpublished material based on the experience of the authors and their collaborators.

This volume deals with structure, preparation and properties of pure carbides, borides, nitrides, and silicides, that is, to the basic constituents of the cemented products now widely used as tool, wear resistant and heat resistant materials. However, it covers also the utilization of hard metals in materials for service at high temperatures, since this particular application involves metal-bonded as well as pure hard metals. The production and application of cemented hard metals is not covered.

Other New Books

REVIEW OF ASTM RESEARCH. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1953. Paper, 8 by 11 in. 22 pp. No Charge.* The material presented here was prepared by the ASTM Administrative Committee on Research, and summarizes the work of the various technical committees of the Society as of May, 1953.

TIMING ENGINEERING. *By Myrten G. Saake. Published by Ribble Engineering Co., Jersey City 2, N. J., 1953. Cloth, 6 by 9 in. 255 pp. Price $5.00.* Here is a complete, full-length reference book on industrial timers and their application. Designed in particular for machine and process designers, the book will impart valuable know how on improved quality and labor saving methods. Timers are covered in their simplest to most complex forms, and the book is liberally illustrated by circuit diagrams in the various applications described.

ENGINEERING METALLURGY. *By Bradley Stoughton, Allison Butts, and Ardrey M. Bounds. Published by McGraw-Hill Book Co., Inc., New York 36, N. Y., 1953. Cloth, 6 by 9 in. 479 pp. Price, $7.50.* Designed for use by the sophomore-junior engineering student who does not plan to specialize in metallurgical engineering, this revised fourth edition is an up to date study of metallurgy. Emphasis here is on aspects of metallurgy necessary in the continuation of courses, and what should be known in the early part of the student's career. Subject matter covered deals primarily with metal utilization rather than production. It covers structure, properties, treatment and working of metals and alloys. Principles and information basic to proper selection of metallic materials in engineering design and construction are given.

Cold-Headed Parts. Townsend Co., 12 pp, ill, No. TL-64. Describes special cold-headed parts for military applications and gives design tips for those planning to use cold-heading. (39)

Steel Tubing. Tube Reducing Corp., 4 pp, ill. Manufacturing process for producing tubing for cylinder applications. (40)

Steel Castings. Unitcast Corp., ill, No. 649-A. Discusses this company's testing facilities for insuring high quality production of steel castings. (41)

Tool Steel. Universal-Cyclops Steel Corp., 8 pp, ill. Description, properties and applications of seven tool steels, designed for specific uses in machining and die work for the fastener industry. (42)

Ferro-Alloys and Metals. Vanadium Corp. of America, 24 pp, ill. "The Vancoram Review" presents technical articles on applications and developments in ferro metallurgy especially concerned with vanadium alloys. (43)

Metal Shapes. Van Huffel Tube Corp., 24 pp, ill. Tables for metal shapes, lockseam tubing, butted tubing, welded tubing, angles and channels. (44)

Stainless Steel Sheet and Strip. Washington Steel Corp., 4 pp. Includes types, uses, physical properties and specifications of MicoRold stainless steel sheet and strip. (45)

Non-Slip Steel Plate. Alan Wood Steel Co., 8 pp, ill. Specifications and characteristics of Algrip abrasive rolled steel floor plate designed for non-skid applications. (46)

Screw Machine Parts and Other Metal Forms. Worthington Corp., 7 pp, No. W-350-B5C. Describes valves, flanges, hose nipples, bars, welding electrodes and screw machine products available. (47)

Continuous Weld Pipe. Youngstown Sheet and Tube Co., 2 pp. Folder gives complete data on Yoloy continuous weld standard pipe and line pipe, and its corrosion resistance. (48)

Nonferrous Metals • Parts • Forms

Die Castings. The Accurate Die Casting Co., 24 pp, ill. Shows company's facilities for producing to order all types of zinc and aluminum die castings. Includes table of alloy properties. (49)

Aluminum Castings. Acme Aluminum Alloys, Inc., 16 pp, ill. Pictures the many facilities of this company for producing a variety of castings, tools and related products. Technical data included. (50)

Aluminum Casting Process. Al-Fin Div., Fairchild Engine & Airplane Corp., 4 pp, ill. Brief articles describing the Al-Fin Process of molecular bonding of aluminum and its alloys to steel, cast iron, nickel or titanium. (51)

Copper and Copper Alloys. American Brass Co., 28 pp, ill. Corrosion Resistance of Copper and Copper Alloys. Includes corrosion theory, types of attack, and thorough tables and corrosion rating charts for standard alloys of copper. (52)

Bronze Bushings, Bearings, Etc. American Crucible Products Co., 12 pp, ill. Technical data on a variety of Promet bronze bushing, bearings, bar stock and babbitt metal available in a series of standard formulas. (53)

Precision Investment Castings. American Precision Casting Corp., 8 pp, ill. Shows the steps involved to obtain precision investment castings using the "lost wax" process. (54)

Magnesium Castings. American Radiator and Standard Sanitary Corp., 8 pp, ill, No. 377. Illustrates the facilities of this company for producing magnesium sand molded casting facilities. (55)

Continuous Cast Bronzes. American Smelting and Refining Co. Catalog gives physical properties, photomicrographs, tables of available shapes and sizes, weights and other technical data. (56)

Zinc Anodes. American Zinc Institute, 30 pp, and 35 graphs. Cathodic protection with zinc anodes. Supplements the report "Zinc as a Galvanic Anode". Includes field test data on zinc anode performance over ten-year history. Case histories and design information with many charts. (57)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings". (58)

Precision Investment Castings. Austenal Laboratories Inc., Microcast Div., 4 pp. Offers a 7-point program covering the Microcast process of precision investment casting. (59)

Beryllium-Copper Springs. Beryllium Corp., 6 pp. Lists advantages of using beryllium-copper as a spring material, and gives physical and mechanical properties. (60)

Magnesium Plate and Sheet. Brooks and Perkins Inc., 4 pp, graphs. Rolled magnesium alloy plate and sheet specifications and weight-strength charts for comparison with other materials. (61)

Thermostatic Bimetal. W. M. Chace Co., 32 pp, ill. Lists 18 uses of thermostatic bimetal as the actuating element in temperature responsive devices, and gives condensed engineering data for bimetal element and design and selection. (62)

Indium. Consolidated Mining and Smelting Co. of Canada, Ltd., 8 pp, ill. Uses, physical and chemical properties and history of Indium metal. (63)

Zinc Die Castings. Dollin Corp., 4 pp, ill. Describes high-speed automatic production of a variety of simple or intricate small zinc die castings. (64)

Nickel Alloy Products. Driver-Harris Co., 4 pp, ill. "D-H Alloy Craftman" describes various applications of Nichrome and monel wires and forms. (65)

Castings. Eclipse-Pioneer Div. Foundries, Bendix Aviation Corp., 4 pp, ill. Discusses facilities of this company for producing a variety of sand, die and permanent mold castings of magnesium and aluminum. (66)

Metal and Plastics Parts. The Electric Auto-Lite Co., Bay Mfg. Div., 16 pp, ill. Shows wide variety of custom-made ornamental and functional metal and plastics parts. (67)

Aluminum Alloy. Fromson Orban Co., Inc., 8 pp. Introductory folder for Lurium, a new high purity aluminum alloy of high brilliance and corrosion resistance. (68)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy combining high strength, good shock and corrosion resistance and machinability. (69)

Contact Rivets. Gibson Electric Co., 6 pp, ill, No. C-521. Description and specifications of a complete line of Gibson electrical contact rivets. (70)

Copper and Brass Tubing. H & H Tube and Mfg. Co., 4 pp, ill. Describes seamless braze and lock seam tubing copper and brass. (71)

Wire Thread Inserts. Heli-Coil Corp., 8 pp, ill, No. 660. Lists advantages of using Heli-Coil stainless steel wire thread inserts in tapped holes. (72)

Precision Investment Castings. Hitchiner Mfg. Co., Inc., 6 pp, ill. Evaluates precision investment casting methods as to costs production and properties of parts. (73)

Bronze Parts. Johnson Bronze Co., 106 pp ill, No. 530. Catalog listing quality bearings, bar bronze, babbitt and powder metallurgy products. (74)

Titanium Carbide. Kennametal Inc., 6 pp, ill, No. 1051. Properties and outstanding characteristics of Kentanium, titanium carbide said to have excellent resistance to heat. Indicates wide variety of possible forms. (75)

Warehouse Service. Korhumel Steel and Aluminum Co., 6 pp, ill. Description of personalized warehouse service for steel, aluminum, phosphor bronze materials and other services. (76)

Magnesium. Magline Inc., 8 pp, ill. Facilities for fabricating magnesium and producing sand castings. (77)

Titanium and Its Alloys. Mallory-Sharon Titanium Corp., 16 pp, ill. Presents general properties, standard product classifications, testing procedures and properties of the five types of titanium and titanium alloys produced by this company. (78)

Magnesium Parts. Magnesium Products of Milwaukee, 4 pp, ill. Briefly describes facilities for designing and producing to order magnesium and aluminum parts. Shows several products. (79)

Nonferrous Castings. Monarch Aluminum Mfg. Co., 4 pp, ill. Describes permanent mold castings made by new process to give high, dense finish of great durability. (80)

Forgings. Mueller Brass Co., 32 pp, ill, No. H-58565. Characteristics and advantages of using brass, bronze and aluminum alloy forgings produced by Mueller. (81)

Tantalum-Zirconium. Murex Ltd., 16 pp, ill. Physical and mechanical properties of tantalum and zirconium with photomicrographs of structure, corrosion resistance tables, etc. (82)

Nonferrous Die Castings. The New Jersey Zinc Co., 28 pp, ill. Applications and principal features of Zamak-3 and Zamak-5 zinc alloy die castings. (83)

Precision Castings. Ohio Precision Castings Inc., 12 pp, ill. Numerous examples of industrial applications of this company's brass bronze, aluminum and beryllium-copper plaster mold castings. (84)

Die Castings. Paramount Die Casting Co., 4 pp, ill. Facilities of this company for producing aluminum, magnesium and zinc die castings. (85)

Copper Tubing. Penn Brass & Copper Co., 6 pp, ill. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (86)

Expanded Metal Meshes. Penn Metal Co., Inc., 24 pp, ill, No. 493 EM. Detailed in-

formation on Penmetal Expanded Metal, sheet metal that has been slit and expanded up to 10 times its original width. (87)

Die Castings. Racine Die Casting Co., 8 pp, ill. Zinc or aluminum castings of various sizes illustrated with facilities for their manufacture. (88)

Thermocouple Wire. Revere Corp. of America, 8 pp, ill. Extruded, braided, tape insulation, flame, oil and moisture resistant wire for use with thermocouples. (252)

Aluminum Mill Products. Reynolds Aluminum Co., 12 pp. Information on wrought alloy fabricating and finishing processes and alloy selection guide for aluminum mill products. (89)

Precision Investment Casting. Alexander Saunders & Co., 12 pp, ill. Advantages in comparison with conventional methods of producing precision investment casting, technique, and equipment and supplies needed. (90)

Bearings, Bushings. Wakefield Bearing Corp., 8 pp. Booklet illustrates Graves, Coprex and Woodex oilless and self lubricating bearings, bushings and machine parts. Also 12-page booklet listing standard sizes of bearings. (182)

Self-Lubricating Bearings. Wel-Met Co., 3 pp, No. 104. Lists 133 MPS standard self-lubricating bearing sizes, and gives inside and outside diameter and length dimensions. (91)

Castings and Patterns. Wellman Bronze & Aluminum Co., 16 pp, ill, No. 53. Includes facilities of this company for producing a variety of nonferrous castings and wood or metal patterns. (92)

Screw Machine Products. Westfield Metal Products Co., Inc., 4 pp, ill. Describes facilities for the production of a variety of machines, nuts and screw machine products. (93)

Nonmetallic Materials • Parts • Forms

Plastic Molding. Ackerman Plastic Molding Div., 4 pp, ill. Long run production of plastic parts by compression or plunger molding. (94)

Aluminum By-Products. Aluminum Co. of America, 4 pp, ill, No. AD-251. Describes company's research facilities and its part in the development of ceramic and gallium by-products. (95)

Thermosetting Plastics. American Cyanamid Co. Thirty success stories show outstanding sales advantages of using Cyanamid plastics, which are hard-wearing, hard-surfaced and hard-to-break. (96)

Heat Resistant Hard Rubber. American Hard Rubber Co., 4 pp, No. 96-B. Describes Ace Tempron, a new heat resistant synthetic hard rubber compound available as molded parts, in sheet, rod and tubing, and standard pipe and fittings. (97)

Ceramics. American Lava Corp., 4 pp, ill. Tables of the mechanical and electrical properties of Al-Si-Mag ceramics. (98)

Corrosion-Proof Structural Plastic. Atlas Mineral Products Co., 6 pp, ill, No. 9-1. Engineering data on Ampcoflex, an unplasticized, rigid polyvinyl chloride for use in corrosion-proof construction. (99)

Balsa Wood. Balsa Ecuador Lumber Corp., ill. Brochure contains a number of sheets discussing various Kilndried Balsa lumber and Balsa products. (100)

Plastic Molding Material. Bolta Products Sales, Inc., 4 pp, ill. Gives characteristics and advantages of Boltaron plastic molding material designed for low cost molding. (101)

Custom Extrusions. Conneaut Rubber & Plastics Co., 4 pp, ill, No. CR-53. Facilities of this company for producing a variety of precision made extrusions. (102)

Molded and Laminated Plastics. Continental Diamond Fibre Co., 12 pp, ill. Specifications for Vulcanized fibre, laminated plastic, fabric-based plastic, spiral tubing, mica-bond tapes and sheets, and teflon sheets and tapes. (103)

Glass. Corning Glass Works, Dept. MM-6, 12 pp. Gives reasons why glass is increasing in importance in product design. (104)

Neoprene. E. I. du Pont de Nemours & Co., Inc. Facts about Neoprene for the engineer. Monthly bulletin #56. (105)

Casting Resin. Durez Plastics & Chemicals, Inc., 16 pp, ill. Technical discussion of Durez 7421A, a phenolic casting resin in liquid form. Includes instructions for use. (106)

Wood-Paper Laminate. David Feldman & Associates, 4 pp. Thin wood veneer laminated to paper for decorative, display, and other uses. (107)

Vinyl Resins. Firestone Plastics Co., Chemical Sales Div., 17 pp. Description and physical properties of Exon vinyl resins. Also test procedures to determine volatile matter, relative viscosity and heat stability. (108)

Flexible Tubing. Flexible Tubing Corp., 8 pp, ill, No. 5-4. Applications and performance data on Spiratube flexible tubing for ventilation and materials conveying. (109)

Industrial Laminates. General Electric Co., 8 pp, ill. Characteristics of Texolite sheets and general properties taken from results of laboratory tests. (110)

Plastics. General Industries Co., 16 pp, ill. Profusely illustrates the facilities of this company for producing a wide variety of low-cost custom-molded plastics. (111)

Vibration Eliminat~r. B. F. Goodrich Co., 4 pp, ill, No. 7290. Includes installation instructions of the Goodrich Vibropad, which muffles shock, noise and vibration of heavy equipment. (112)

Polyvinyl Chloride Resins. B. F. Goodrich Chemical Co., 16 pp, ill, No. G-8. Bulletin discusses the materials and factors used in calendering, extrusion and injection molding compounds. (113)

Plastic Adhesive. Goodyear Tire & Rubber Co., Inc., 24 pp, ill, No. S-9416. Properties, applications, specifications and data sheets of Pliobond, a quick-setting plastic adhesive that bonds anything to anything. (114)

Resin-Rubber Material. Goodyear Tire & Rubber Co., Chemical Div., 24 pp, ill, No. S-9492. Detailed tabular data on Pliolite S-6B, a thermoplastic resin for use in the manufacture of rubber products. (115)

Industrial and Laboratory Chemicals. The Harshaw Chemical Co., 16 pp, ill. Chemicals for catalysis, electroplating and other uses. Pigment and ceramic materials, synthetic optical crystals. Description of research facilities. (116)

Corrosion Resisting Plastic. Haveg Corp., 8 pp, ill. Uses of various grades of Haveg material, an asbestos with synthetic resin for corrosion resisting process equipment. (117)

Plastics. Heresite & Chemical Co., 24 pp, ill. Oil-free thermosetting phenolic coatings, thermosetting and thermoplastic resins, molding compounds, synthetic rubber coating sheets and molded forms. (118)

Leather Packings. E. F. Houghton & Co. Synthetic-rubber, impregnated-leather cup packings for plastic flow and extrusion resistance. (119)

Balsa Wood. International Balsa Corp., 4 pp, ill. Unusual physical properties of balsa wood and a list of many potential uses that have scarcely been tapped. (120)

Rigid Polyvinyl Chlorides. Kaykor Industries Inc., Div. of Kaye-Tex Mfg. Corp., 6 pp. Chemical and physical properties of Vyflex rigid polyvinyl chloride plates and sheets. (121)

Molding Powders, Etc. M. W. Kellogg Co., 20 pp. Buyer's Guide gives complete addresses of firms producing molded and fabricated materials and products made of Kel-F, a trifluorochloroethylene polymer offered by Kellogg. (122)

Furfuryl Alcohol Resin. Maurice A. Knight Co., 4 pp, ill, No. 6. Properties, uses and applications of Permanite alcohol resins used in the fabrication of corrosion-proof chemical equipment. (123)

Glass. Kopp Glass Inc., 18 pp, ill. Methods by which Kopp glass products are designed and made to meet strict specifications for light transmission and distribution, physical properties, dimensional exactness and other requirements. (124)

Polystyrenes. Koppers Co., Inc., No. C-2-169. Features a table giving all the properties of a complete line of straight and modified Koppers polystyrenes. (125)

Glass. Libbey-Owens-Ford Glass Co., 8 pp, ill, No. SPD. Describes a variety of types of glass for decorative and functional purposes, giving typical uses, properties and available sizes. (126)

Carbon Products. Morganite Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (127)

Mica Insulation. Mycalex Corp. of America, 24 pp, ill, No. VI. Engineering data on Mycalex, a glass-bonded mica insulation for all frequencies. (128)

Polyester Resins. Narmco Resins and Coatings Co., 4 pp. Physical characteristics, shelf and pot life data for two polyester resins and two putties, #3117 to #3120. (129)

Refractories. Norton Co., 24 pp, ill. Uses and characteristics of four major refractories supplied in grain shapes and cements. (131)

Electrical Insulating Materials. Owens-Corning Fiberglas Corp., 36 pp, ill. Technical data and applications of a complete line of glass-base electrical insulating materials. (132)

Fiber Glass. Pittsburgh Plate Glass Co.,

Fiber Glass Div., 4 pp. Specifications, technical data and typical applications of Pittsburgh Superfine Fiber Glass for insulation purposes. (133)

Plastic Glass Laminate. Plastilight Inc., 1 pp, ill. Technical data on Epoglass (epoxy resin laminate) for use in electrical and electronic systems such as printed circuits. (134)

Molded Plastics Products. Pro-Phy-Lac-Tic Brush Co., 13 pp, ill. Discusses this company's molding equipment, assembling facilities, and research and testing departments. (135)

Extruded and Molded Rubber Parts. Republic Rubber Div., 12 pp, ill. Describes facilities for custom manufacture of molded and extruded rubber products. Describes various products. (136)

Flexible Hose. Resistoflex Corp., 4 pp, ill. Includes chemical and physical properties and typical applications of Resistoflex flexible hose. (137)

Plastic Parts. The Richardson Co., 4 pp, ill. Laminated and molded Insurok for fabricated parts, gear stock, etc. Uses of molded Insurok, in many other applications. (138)

Closed Cellular Rubber. Rubatex Div., Great American Industries Inc., 8 pp, ill. Nonporous foamed rubber product for sealing, gasketing, cushioning, packaging, and other uses. (139)

Molded Rubber Parts. Rubber Products Div., Parker Appliance Co., 4 pp, ill, No. 5201A. Lists the many advantages of using Parker custom molded rubber parts in a variety of applications. (140)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds, designed to resist temperature, abrasion, chemicals and weathering. (141)

Ceramic Laboratory Ware. The Thermal Syndicate Ltd. Technical descriptions, specifications and prices of Vitreosil ware, said to be superior to porcelain in some uses. (142)

High Temperature Insulation. H. I. Thompson Co., 34 pp, ill. Detailed technical data on Refrasil, giving case histories on performance characteristics as a high temperature insulator. (143)

Rubber Products. U. S. Rubber Co., 25 pp, ill, No. M-9012. Detailed description of new research and development laboratory, indicating its place in development of rubber products (144)

Plastic-Rubber Blends. U. S. Rubber Co., Naugatuck Chemical Div., 20 pp, ill. Fabricating methods, applications and general types of Kralastic blend of rubber and plastic. Illustrates many ways of using Kralastic in extrusion and injection molding. (145)

Felt. Western Felt Works, 32 pp, ill. History of manufacture and uses of felt, including brief description of present-day methods and applications. (146)

Nonmetallic Gears. Westinghouse Electric Corp., 15 pp, ill, No. B-4661. Description and applications of Micarta gears. Includes tables of properties, gear data and preferred pitches. (147)

Finishes • Cleaning and Finishing

Magnesium Coating. Allied Research Products, Inc., folder. Announcement of Iridite #15, an easily-applied, corrosion-resistant finish of the chemical-dip type for magnesium. (183)

Protective Coating for Aluminum. American Chemical Paint Co., 4 pp, ill, No. 586B. Describes application, characteristics and advantages of "Alodine" phosphate coatings for aluminum. (148)

Aluminum Coating. Anodic Inc., 4 pp, with sample. Hard coating for aluminum—its properties and uses. (149)

Surface Treatment. Buffalo-Electro Chemical Co., Inc., 13 pp, No. 51, Part 2. Surface treatment of metals with peroxygen compounds, including bright dips, cleaning solutions, passivation and inhibitors. (150)

Zinc-Plate Bright Dip. The Chemical Corp. Information on Luster-On Utility-25 bright dip for zinc-plated surfaces. Highly resistant to corrosion. (151)

Hard Facing. Cleveland Hard Facing Inc., 4 pp, ill. Services for hard facing parts subject to intense wear conditions. (152)

Ultrasonic Cleaning. Detrex Corp., 4 pp, ill. Description of Soniclean ultrasonic metal parts cleaning process machinery. (153)

Black Oxide Finish. Du-Lite Chemical Corp. Information on Du-Lite finishes for any steel blackening problem. Also gives information on Du-Lite cleaner, strippers, burnishing compounds, etc. (154)

Neoprene Coating. Gates Engineering Co., 4 pp, ill. A liquid, air-curing Neoprene coating for chemical resistance, resiliency, elasticity, toughness and weather resistance. (155)

Chemical Plating. General American Transportation Corp. Large illustrated folder. Description of Kanigen, a new type of nickel plating process requiring no electrical equipment. (156)

Protective Coatings. Industrial Metal Protectives, Inc. Illustrated brochure describing Zincilate, which can be applied by spray, brush dip or flow coat methods to new products or existing structures. (157)

High-Pressure Cleaners. J. P. Mfg. Co., 4 pp, ill. Typical applications of the new 2500 Series Whirlpool high pressure cleaners that degrease, wash, strip and clean in one operation. (158)

Metal Finishing Chemicals. Klem Chemicals Inc., 12 pp. Listing of 33 standard products with application charts for surface preparation of ferrous and nonferrous metals permits processers and finishers to select the correct chemicals for various operations. (159)

Mechanical Finishing. Mecha-Finish Corp., 4 pp, ill. Low cost deburring and finishing abrasives chips. (160)

Hard Surfacing. Metallizing Engineering Co., Inc., 4 pp, ill. Metal spraying and torch fusing are combined for simplified high-speed application of superhard surfacing alloy. (161)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 241 or 242

Tin Brightening. Metal & Thermit Corp., Chemical Div., 2 pp. Data Sheet No. 120. Describes the flowing (brightening) of electrodeposited tin. Process, equipment and solutions are described, as are common difficulties and their correction. (162)

Metallizing. Coating Div., Metalweld Inc., 4 pp, ill. Application, use and benefits obtained in metallizing. Data on a new spraying technique widening application possibilities. (163)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish, said to resist heat of 500 F without discoloration. (164)

Barrel Finishing. Minnesota Mining and Mfg. Co., 12 pp, ill. Abrasive compounds for use in barrel finishing for deburring and burnishing. (165)

Dry Acid Pickle. The Mitchell-Bradford Chemical Co., 1 p. Specifications and characteristics of "Quick Pik" acidic salt mixture for removing scale and rust. (167)

Aluminum-Chromium Paint. Monroe Co., Inc., 4 pp, ill, No. C-54-8. Includes detailed application data on Monco-alochrom, an aluminum-chromium paint for exterior surfaces of all kinds. (168)

Micropolishing. The Murray-Way Corp. Engineering specifications and auxiliary equipment needed for micropolishing. (169)

Metal Cleaner. Niagara Alkali Co. Pamphlet gives properties of Nialk Trichlorethylene, high quality metal-cleaning and degreasing agent. (170)

Aluminum Cleaner. Northwest Chemical Co., 10 pp, ill. Attractively presents information on the Alkalume Process for preparing aluminum for spot welding. (171)

Steel Coating. Oakite Products Inc., 12 pp, ill. Explanations of problems involved in securing paint adhesion to steel and protecting painted surfaces from electrochemical corrosion. Action of Oakite CrysCoat HC in coating steel surfaces. (172)

Plating Baths. Promat Div., Poor & Co., 4 pp, ill. Condensed information on a variety of zinc, cadmium, copper and white alloy plating baths that meet today's metal finishing requirements. (173)

Preparation for Galvanizing. Riverside Foundry & Galvanizing Co., 4 pp, ill. Recommendations for proper preparation of materials prior to hot-dip galvanizing. (174)

Electroplated Rhodium. Technic Inc., 1 p. Technical data sheet on electroplated rhodium also announces the availability of heavy rhodium plated deposits. (175)

Zirconium Glazes for Ceramics. The Titanium Alloy Mfg. Div., 30 pp. Description, uses and properties of TAM zirconium glaze opacifiers. (176)

Burnishing. Tumb-L-Matic Inc., No. BB-52. Features, operation and specifications of conventional wooden and molded barrels of high abrasion resistance material. (177)

Protective Coating. United Chromium, Inc., 4 pp, ill, No. MC-4. Describes four different groups of Ucilon corrosion resistant coatings, giving properties, advantages and case histories. (178)

Protective Coatings. U. S. Stoneware Co., 16 pp, ill, No. 730. Gives applications of Tygon Paint and Tygorust Primer. Includes charts on chemical resistance and recom-

MANUFACTURERS' LITERATURE

mended primers and surface treatments. (179)

Thermoplastic. Van Dorn Iron Works Co., 16 pp. Technical data on properties, available forms, fabrication and applications of Lucoflex, a rigid polyvinyl chloride. (180)

Liquid Honing. Vapor Blast Mfg. Co., 4 pp, ill. Equipment for surface finishing by liquid honing, specifications and dimensions of equipment. (181)

Heat Treating • Heating

Heat Treating Furnaces. A. D. Alpine Inc., 4 pp, ill. Gives features and specifications of six Contro-Therm heat treating furnaces for all types of heat treating, soldering and brazing. (184)

Continuous Quenching Tanks. American Gas Furnace Co., 4 pp, ill, No. 820. Specifications of complete line of continuous automatic quenching tanks. Shows several factory installations. (185)

Furnace Heating Elements. Carborundum Co., Globar Div. Complete data on Globar silicon carbides heating elements, said to be efficient, safe and easy to repair. (218)

Heat Treating Furnaces. The Electric Furnace Co., 4 pp, ill. Shows various gas, oil and electric furnaces for annealing and heat treating requirements and lists applications. (186)

Electric Furnaces. Harper Electric Furnace Corp., 4 pp, ill, No. 252. Presents features and specifications of furnaces for all types of research and small scale production. (187)

Heat Treating. Hevi Duty Electric Co., 4 pp, ill. Endothermic generator, a controlled atmosphere generator for production heat treating, description and operational features listed. (188)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, ill, No. B-5459. Complete description of Westinghouse furnaces—large and small, gas and electric. (189)

Air Compressors. The Spencer Turbine Co., 12 pp, ill, No. 126-A. Performance curves, capacity tables and detailed descriptions of Turbo compressors for use in gas or oil fired heat treating equipment. (190)

Quenching Oils. Sun Oil Co., 8 pp, ill, No. A-2658. Complete data on Sun quenching oils, which can handle 95% of all quenching jobs in industrial heat treating. (191)

Heating Furnaces. Surface Combustion Corp., 4 pp, ill. High-speed heating furnaces for press forging, upsetting, extruding, stress relieving, etc. (192)

Heating Units. Edwin L. Wiegand Co., No. 50. Catalog describes this company's industrial heating units, giving specifications and features. (193)

Welding • Joining

Inert Arc Welding. Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 7 pp, ill. Reprint of article "Will Inert Gas Metal Arc Save Money on Mild Steel?" Graphs and cross section photos and welding data recorded in tables. (194)

Hardfacing Rods. American Manganese Steel Div., American Brake Shoe Co., 4 pp, ill. Discusses a variety of Amsco manganese and hardfacing rods for hardfacing and manganese steel bars and shapes for controlling impact and abrasion. (195)

Brazing Alloys. The American Platinum Works, 46 pp, ill. Handy-sized manual gives detailed description of the brazing process, the alloys used, design of joints and other considerations for successful joining. (196)

Low Hydrogen Welding Electrodes. Arcos Corp., No. 45118. Folder contains questions and answers on low hydrogen electrodes, selector chart for welding high strength steels and specification data on the new Tensilend electrodes. (197)

Bonding Resins. Ciba Co., 4 pp, ill. Properties of new group of resins, their applications as adhesives for metals and nonmetallics, moldings and coatings. (198)

Resin Bonding Agents, Fluxes, Etc. Eutectic Welding Alloys Corp., ChemoTec Div., 52 pp, ill. Contains procedure sheets and technical data on a complete line of ChemoTec organic metallic bonding agents, specialized fluxes, surface conditioners and metallic fillers,. (199)

Joining Rubber-Lined Pipes. Gates Engineering Co., 12 pp, ill. Advantages and specifications of the Gaco rubber-lined pipe joint process of joining and replacing rubber-lined pipe. (200)

Constant Voltage Welders. Glenn Co., 4 pp, ill. Features and advantages of constant voltage type of welder for automatic processes such as inert gas submerged arc stud welding and semi-automatic welding. (201)

Wing Nuts. Gries Reproducer Corp. Data on zinc alloy wing nuts, said to be strong, rust-proof, low cost, available in all commercial finishes and thread sizes. (202)

Brazing. Handy & Harman, ill, No. 54. "Brazing News" describes applications and developments of Easy-Flo and Sil-Fos low temperature silver brazing alloys. (203)

Fastenings. H. M. Harper Co., 8 pp, ill, Vol. 17, No. 1. "Harper Bolt News" is published in the interest of users of rust and corrosion resisting fastenings. Features flood control units, bubble caps and trays, and part one of article on corrosion resistant fastenings. (204)

Welding Speed Steels. W. J. Holliday & Co., 4 pp, ill, No. 907. Detailed information on welding Speed Case (X1515), Speed Treat (X1545) and Speed Alloy Plate. (205)

Welding Nickel Alloy Steels. International Nickel Co., Inc., Development & Research Div., 43 pp, ill. Study of various welding techniques, including some of the new inert gas processes, electrodes, preheat treatments and postheat treatments. (206)

High Frequency Heating Units. Lepel High Frequency Laboratories, No. MM-7. Specifications, features and advantages of this company's low cost, high frequency heating units. (207)

Weld Design. Lincoln Electric Co., 6 pp, ill, No. 8438. Fifth in a series of "Elements of Weldesign" explains how to shape steel for low cost, using Lincoln's Weldesign methods. (208)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 241 or 242

Stainless Steel Electrodes. The McKay Co., 48 pp. Data on arc welding of stainless steels, giving specific uses of alloying elements and specifications of each type of McKay stainless steel electrode. (209)

Fasteners. Milford Rivet & Machine Co., 12 pp, ill, No. MM52. Detailed information on an integrated service of fastener research, design, engineering and production collaboration. (210)

Arc Welders. Miller Electric Mfg. Co., 4 pp, ill. A complete line of transformer type welders for all applications of Heliarc processes. (211)

Gold and Platinum Solders. The J. M. Ney Co., 1 p. Data sheet gives melting ranges and colors of this company's gold and platinum solders for electronic tube applications. (212)

Stainless Steel Fastenings. Star Stainless Screw Co., 16 pp, ill, No. 52-A. Offers detailed specifications to aid in selecting and ordering a variety of stainless steel fastenings. (213)

Copper-Aluminum Welding. Taylor Winfield Corp., 4 pp, ill. Description of the technique of resistant flash-butt welding for joining copper to aluminum. (214)

Welding Steel Castings. Tempil Corp., 11 W. 25th St., New York, N. Y., 40 pp, ill. Technical data book on the recommended practice for the welding of steel castings, prepared and published by the Steel Founders' Society of America. Request direct from Tempil on company letterhead.

Nut Fasteners. Tinnerman Products Inc., No. 326. Describes wide variety of speed nut and clip fasteners, said to be adaptable for most types of material or to all thread systems. (215)

Welding Positioners. Worthington Corp. Industrial Div., 36 pp, ill, No. 210C. Description, features and applications of 100 to 40,000-lb capacity welding positioners. (216)

Forming • Casting • Molding • Machining

Belt Grinders and Finishers. Behr-Manning. Describes advantages of belt finishing and grinding, shows this company's equipment and suggests methods for cost cutting. (217)

Machining Equipment. The Cincinnati Milling Machine Co., 48 pp, ill, No. M-1712. Features and specifications of this company's automatic flame hardening machines, grinding machines and milling machines. (219)

Springtites and Sems. Eaton Mfg. Co., 4 pp, ill, folder C-49a. Thread cutting and self tapping springtites and sems. Dimensions. (220)

Tabletting Presses. F. J. Stokes Machine Co., 24 pp, ill. Describes complete line of Stokes single-punch and rotary tabletting presses for compacting pharmaceuticals, powder metals, plastic preforms, etc. (221)

Machining Laminated Plastics. Synthane Corp., 6 pp, ill. Recommended techniques for common machining operations on laminated plastics. Includes properties and design hints. (222)

MANUFACTURERS' LITERATURE

Hole Punching Units. Wales Strippit Corp. 8 pp, ill. Equipment described for punching holes in curved and straight flanges and in rims. (223)

Presses. Watson-Stillman Co., 8 pp, ill, No. 110-C. Features a variety of metal working, extrusion, hobbing and railroad presses, as well as plastics molding machinery, etc. (224)

Adjustable Perforating Dies. S. B. Whistler & Sons Inc. Catalog describes this company's line of adjustable perforating dies for punching holes in sheet metals. Includes prices and applications. (225)

Inspection • Testing • Control

Laboratory Chemicals. Allied Chemical & Dye Corp., General Chemical Div., 264 pp, ill. Catalog of laboratory reagents and chemicals describes their properties, specifications, storage, packaging and other data. (226)

Industrial Radiography. Atomic Energy of Canada Ltd., Commercial Products Div. Up-to-date information on nondestructive testing of metals by gamma radiography. (227)

Optical Aids in the Metal Working Industries. Bausch & Lomb Optical Co., 16 pp, ill, No. D-22. Includes specifications of a complete line of Bausch & Lomb optical aids in the metal working industries. (228)

Fine Grinders. Buehler Ltd., 4 pp, ill. Fine metallurgical grinding machines for the laboratory, hand grinders and abrasives. (229)

Ultrasonic Measurement. J. W. Dice Co., 4 pp, ill. Specifications and instructions for use of Ultrasonic Metroscope for measuring wall thicknesses of metal plates or parts. (230)

Magnifying Contour Projector. Eastman Kodak Co., 8 pp, ill, No. F1-23. Operating principle, applications, features, specifications and accessories of this firm's contour projector. (231)

Pyrometers. General Electric Co., 12 pp, GEC-713B. Booklet describes G.E. line of indicating and controlling pyrometers, including design features, applications, operations, functional principles, construction and specifications. (232)

Metallurgical Laboratory Equipment. Harshaw Chemical Co., Harshaw Scientific Div., 12 pp, ill, No. D2637. Catalog describes and gives specifications of this company's available metallurgical laboratory equipment. (233)

Bend Test Machine. Krouse Testing Machine, 4 pp, ill, No. 46-W. Specifications and description of high capacity repeated bending machine. (234)

Relation of Machining Time to Material Cost. La Salle Steel Co., 12 pp, ill, No. 9. Reprint gives helpful data on the relation of machining time to materials cost, including a comparative machinability chart and a profit selector chart for steel bars. (235)

Profilometer. Micrometrical Mfg. Co., 1 p, ill. Announcement of the profilometer type KC Tracer with dogleg beam for measuring roughness of internal tapers and other hard-to-reach surfaces. (236)

Program Controllers. Minneapolis Honeywell Regulator Co., Brown Instruments, 8 pp, ill. Electronic strip chart program controllers. Models available, structure details, typical applications and specifications. (237)

Impact Testing Machines. National Forge & Ordnance Co., Testing Machine Div., 4 pp, ill, No. 523. Discusses a new low capacity impact tester for plastics, ceramics and light metals. Includes specifications. (238)

Spectrographs. National Spectrographic Laboratories, Inc., 4 pp, ill, No. 300. Description, operating principle and control features of spectrograph units for both quantitative and qualitative analysis. (239)

Metal Hardness Testers. Newage International, Inc., 1 p, ill. Data on the new Ernst Rockwell A, B and C scale and Brinell low and medium range portable metal hardness testers with direct reading of Rockwell 15N scale 70-95. (240)

Radiation Pyrometer. The Pyrometer Instrument Co., No. 100. Features and principle of Pyroradiation pyrometer for obtaining spot temperatures in furnaces, kilns, forgings and fire boxes. (241)

Thermocouples. Revere Corp. of America, 4 pp, ill. Precision thermocouples of various types and accessory equipment. (242)

Testing Service. South Florida Testing Service, ill, folder. Enginering laboratory described for inspection, research and testing services for paints, plastics, rubber, metals, woods, paper, etc. (243)

Testing Services. Sperry Products Inc., 8 pp, ill, No. 50-115. Shows typical tests on materials carried out by this firm's engineers for a great variety of companies using Reflectoscope and Reflectogage. (244)

Testing Machines. Steel City Testing Machines Inc., 4 pp, ill, No. G-252. Describes and illustrates a complete line of Brinell hardness testing machines. (245)

Pyrometer Wire Color Codes. Thermo Electric Co., Inc. Handy chart gives pyrometer color codes, calibration symbols and parts meeting ISA, military and aeronautical specifications. (246)

Impact Tester. U. S. Testing Co., Inc., 2 pp, ill. Includes history, description and use of the SPI low temperature impact tester. (247)

Hardness Testers. Wilson Mechanical Instruments Co., 12 pp, ill, No. DH-114. Descriptions and specifications of several Tukon hardness testers. Includes discussion of hardness testing and applications. (248)

General

High Vacuum Pumps. Consolidated Vacuum Corp. Data on high vacuum pumps of unique design for such uses as metal processing and dehydration. (249)

Decimal Equivalent Chart. John Hassall, Inc. Easy-to-read decimal-equivalent wall chart of this company's cold headed parts. (250)

Materials Controls. Remington Rand Inc., No. KD 367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (251)

Industrial Chilling Equipment. Sub-Zero Products Mfg. Div., Deep Freeze Distributing Corp., 8 pp, ill. Specifications and uses of industrial chilling machines for shrinking, testing and treating of metals. (253)

The Editor's Page

Mixed Emotions

We are always happy to see the development of new words which give promise of making our language more colorful. At the same time we dislike the idea of Washingtonese getting too strong a grip on the tongue. These thoughts were stimulated by our first sight of a new (to us at least) word—"productionizing". Apparently what is meant is that something is being put into production. After materials have been selectionized, and designs finalized, the object can be productionized.

That's Over

If it were not for the fact that acquaintanceships with many old friends are renewed each year at the Metal Show, that entire trip could be extremely frustrating. This year, the show was bigger, brassier, and busier than ever, and roller skates or a motor scooter should have been furnished to all visitors. It will take several months before I grow back the inches of leg I wore away covering those concrete acres. As usual the debate now rages as to whether the show was worthwhile. I've heard many expressions on both sides of the argument, with perhaps an edge going to those who feel that the whole thing is just too big. With them I concur.

What Show?

Incidentally there seems to be much confusion as to just what the show is all about. Of course, we have all known the affair as the Metal Show for lo these many years. This year, newspapers in Cleveland and New York called it the Tool Show. To further complicate matters, we understand the name is to be changed officially to the Metal Working Show. Take your choice.

Helping Hands

This is something we have no hand in so we can comment without bias. Have you noticed that many advertisers in recent months have been publishing highly informative advertisements? In addition to those which really give good product information, others bring us up to date on particular fields. Here is one: "Transistors When?" (Minneapolis-Honeywell), from the October issue of Materials & Methods. This is a special ad, but many advertisers provide good help month after month in their regular product promotion. I think most readers appreciate good helpful advertising, and consider it a worthy frosting on the regular editorial cake.

Look At Your Bills

Perhaps the remainder of the country has not been so fortunate, but the New York area is plagued with a deluge of valuable dollar bills circulated by newspapers seeking to increase circulation. Business comes to a standstill every morning while everyone from president to office boy scans the list of Lucky Bucks and Bonanza Bills. It's questionable whether Materials & Methods will enter into the same kind of promotion. Anyhow our circulation is coming along nicely without either giving the magazine away or developing a lottery to get people to look at it.

Where It Started

The recent death of Dr. Colin G. Fink of Columbia University, has uncovered some interesting facts about chromium plating, a process which was developed by Dr. Fink. The first successful plating of chromium was done in 1925 and the first objects so plated by the commerical process were a set of door knobs. Recently, the historic door knobs were retired from active duty, after 29 years, and placed in a museum. For comparison, they might take my rusty auto bumpers to show how far backward the art has progressed in less than thirty years.

T. C. Du Mond
Editor